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MODELS 7350A & 7360A-57

Universal EPUT® & Timer

Beckman®

Operating and Servicing Manual

Electronic Instruments Division

MODELS 7350A & 7360A-S7

Universal EPUT® & Timer

SERIAL NO. _____

Beckman®

INSTRUMENTS, INC.

ELECTRONIC INSTRUMENTS DIVISION
RICHMOND, CALIFORNIA • 94804

1959
(REV. 1-67)

BII No. 015-436108

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MODEL 7360R-57

This modification (-57) includes special interior spray of instrument for fungus proofing.

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MODIFICATION A

The Model 7350 has been modified to increase its frequency range from 100 Kc to 500 Kc. The modified instrument is indicated by an "A" following the model number. Specifications for this instrument are:

Frequency range:	DC to 500 kHz
Resolution:	2 microseconds

Model 7360 has been modified to increase its frequency range from 1 MHz to 2 MHz. Specifications for this instrument are:

Frequency range:	DC to 2 MHz
Resolution:	0.5 microsecond

This modification has resulted in the following changes to the Models 7350 and 7360 Indicator Schematic Diagrams:

1) A206 was changed from a 775 DCU to a 785A DCU, and additionally in the case of the Model 7360, A207 was changed from a 785A to a 795A DCU.

   (Note that 785 and 785A DCU's are completely interchangeable as are Models 795 and 795A)

2) R231, R232, R233, and R234, connected to pins 6, 2, 10, and 9, respectively on XA207, were moved to the respective pins on XA206.

3) B^+, Y, Y^1, and GND, connected to pins 5, 1, 11, and 3 respectively on XA207, were moved to the respective pins on XA206.

4) Add R266 from pin 5 of V204 to +120 V (also shown on component layout drawing No. B401693).

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COMPONENT LAYOUT DRAWINGS	Dwg. No.
Reset - Models 7350A & 7360A	(B 401723)
Function Switch - Models 7350A & 7360A	(C 402215)
Attenuator Switch - Models 7350A & 7360A	(A 401683)
"A" or "B" Input Channel - Model 7360A	(B 402188)
Power Supply - Models 7350A & 7360A	(C 401700)
Time Base - Model 7350A	(B 402068)
Time Base - Model 7360A	(B 402139)
Signal Gate - Model 7350A	(B 401693)
Signal Gate - Model 7360A	(B 413454)
Pot Bracket - Model 7350A	(C 402093)
Pot Bracket - Model 7360A	(C 402148)
100 kc Oscillator - Model 7350A	(B 402047)
1 Mc Oscillator - Model 7360A	(B 402054)

DIAGRAMS	
Outline Drawing	(C 401911)
Model 7350A Indicator Schematic Diagram	(D 411134)

continued. . .

DIAGRAMS - continued

	Dwg. No.
Model 7360A Indicator Schematic Diagram	(D 413542)
Model 7360A 1 Mc Divider Chain Schematic Diagram	(D 410586)
Model 7350A 100 kc Divider Chain Schematic Diagram	(D 410587)
Oscillator and Shaper Schematic Diagram	(C 410724)
Input Channel Schematic Diagram	(C 410723)
"A" or "B" Input Channel Schematic Diagram	(C 412829)
Power Supply Schematic Diagram	(C 408695)

APPENDICES

Supplementary Service Notes, SSN7000

Modifications 7000/8000

Model 775 Decimal Counting Unit Instruction Manual

Model 785 Decimal Counting Unit Instruction Manual

Model 795 Decimal Counting Unit Instruction Manual

Figure 1 Front View of Model 7360

1 Introduction

DESCRIPTION

The Universal EPUT® and Timer (Models 7360 and 7350) is an electronic counter which will perform a wide variety of frequency and time measurements. These various functions are described below under "SPECIFICATIONS". The instrument consists of a precision clock-pulse generator, two input pulse-forming (trigger) channels, an electronic gate and a chain of decimal counting units (DCU's). When measuring frequency, each input signal cycle triggers a sharp voltage pulse on one of the input channels. These pulses pass through the gate and are counted by the DCU's during a precise time interval established by the clock-pulse generator. When measuring time, clock pulses are let through the gate and counted during an interval controlled by input signals.

The Model 7360 differs from the Model 7350 primarily in the highest frequency which may be measured and in the smallest unit of time measurement available. The Model 7360 will measure frequencies as high as 1 MC, whereas the Model 7350 is limited to 100 KC. The Model 7360 will make time measurements in one-μsecond units while the smallest unit of time measurement on the Model 7350 is 10 μseconds.

SPECIFICATIONS

FUNCTIONS

1. Measures frequency or counts events-per-unit-time over a maximum automatic time interval of 10 seconds with a manual extension beyond 10 seconds for extreme accuracy.

2. Measures period of a wave or the width of a pulse. Measures ten periods when greater accuracy is desired.

3. Measures the time interval between two events represented by pulses on separate input channels. When a signal is applied to one channel and the same signal is a different phase to the other channel, the result of this measurement is the phase difference.

4. Counts the number of events occuring between two events represented on the same input channel. If the events to be counted are cycles of a signal of one frequency and the two events which begin and end the counting period are successive cycles of a lower frequency, the result of this measurement is the ratio of the frequencies.

5. Counts events over a manually controlled time interval.

6. Makes self-check on functioning of clock signals and Decimal Counting Units.

7. Performs any of the above functions with an appropriate external frequency substituted for the internal oscillator frequency.

PERFORMANCE CHARACTERISTICS

Input Trigger Channels

Input frequency range
d-c to 1 MC

Input impedance
10 megohms in parallel with 40 $\mu\mu f$

Input sensitivity
100 millivolts rms, 0.3 volts peak-to-peak from d-c to 1 MC

Input voltage attenuation
1, 10 or 100 a-c and d-c

Overload limits
Input impedance drops below 10 megohms when input voltage rises above +1 volt d-c after attenuation.

Trigger voltage level
Adjustable from -1 to +1 volt at the attenuated signal

Trigger slope
Plus or minus

Clock-pulse Generator

Output frequency
Selectable in decade steps from 1 cps to 1 MC on the Model 7360 and from 1 cps to 100 KC on the Model 7350

Output signal
0.1 microsecond rise time 2 volts high to open circuit source impedance 330 ohms.

Oscillator stability
Model 7360: 2 parts in 10^7 per day
3 parts in 10^7 per week
Model 7350: 1 part in 10^6 per day

Gate, Control Circuits and DCU's

Resolution
Model 7360: 0.8 microseconds
Model 7350: 5 microseconds

Capacity
Model 7360: 10^7 counts
Model 7350: 10^6 counts

Display
Continuously variable from 0.1 to 10 seconds.

4-line code from DCU's to external connector.

APPLICATIONS

The Universal Eput & Timer can be used to make a wide variety of frequency and time measurements both in the laboratory and on the production line. It is useful in designing transmitters, receivers, tuned circuits, crystals, oscillators and other equipment which must have definite frequency characteristics. On the production line the instrument is ideal for making stability checks on transmitting and receiving equipment and on crystals during heat cycling. It may also be used to calibrate less accurate frequency monitoring equipment.

Various transducers such as photocells, magnetic pickups and switches may be used to produce voltage changes representing physical events. So equipped, the instrument will measure the characteristics of such events relative to time. Some of the known applications of the instrument are:

Frequency measurements
Frequency ratio measurements
Relay and switch timing
Phase measurements
Viscosity and ballistic measurements
Elasticity measurements
Tachometry
Telemetery
Pulse height analysis
Oscilloscope time base calibration
Use as a secondary frequency standard

The versatility of the instrument can be fully utilized only when it is equipped with the proper accessories. Numerous transducers such as the Model 441 Reflecting Tachometer, as well as sev-

eral data recording and data reduction instruments are available at Berkeley. The Model 1452 Digital Recorder, designed for use with this instrument, converts count information into a printed record. The unit prints the count accumulated by the counter during each counting period. The printed count appears sequentially in Arabic numerals on a standard adding machine tape. This recorder is ideal for making long term stability checks, recording transients, monitoring, or for making a permanent printed record in control or measuring systems.

The Beckman/Berkeley, Data Reduction Converters, convert digital information from the counter to a form suitable for actuating an IBM summary punch or an electric typewriter. These converters have uses similar to those of the Digital Recorder.

Berkeley Digital to Analog Converters convert the count accumulated during each counting period to a representative voltage level. This voltage is held until a new count is completed when it changes to conform with the new count. The unit may be used with a self-balancing potentiometer to provide an analog record, or the changing voltage level may be used to control the operation being monitored.

All accessory units described are available as standard models. In addition, special or modified versions can be ordered for specific applications.

NOTE

The Model 7350 has been modified to increase its frequency range from 100 kc to 500 kc. The modified instrument is indicated by an "A" following the model number. Specifications for this instrument are:

Frequency range:	DC to 500 kc
Resolution:	2 microseconds

Model 7360 has been modified to increase its frequency range from 1 Mc to 2 Mc. Specifications for this instrument are:

Frequency range:	DC to 2 Mc
Resolution:	0.5 microsecond

2 Operation

OVER-ALL DESIGN

The counter will make three types of measurements aside from simple counting.

1. It will count the number of events occuring during a precise time interval. This is known as Events-Per-Unit Time or E/UT Operation. Frequency measurements are made in this way. The SCAN function is a variation of this operation.
2. It will measure the time interval between two events. If the two events are represented by voltage changes on separate input channels, it is called Time-Interval-Measurement or TIM Operation. If the two events are represented on the same input channel this is known as PERIOD Operation.
3. It will count the number of events occuring between two other events. This is Ratio or A/B Operation.

If the events mentioned above are not initially voltage changes, appropriate transducers are used to produce voltage changes representing the events at the counter INPUTS. Two input trigger channels within the counter convert the voltage changes they receive into sharp pulses. A clock-pulse generator in the instrument produces similar pulses separated by a precise time interval. Besides these three pulse sources the counter contains an electronic gate and a chain of decimal counting units. (DCU's). The DCU's count and indicate the number of pulses which pass through the gate between a start pulse which opens it and a stop pulse which closes it.

The FUNCTION switch determines the type of measurement made by selecting the pulse source which provides each of the three signals -- pulses to be counted, the start pulse and the stop pulse.

1. Under E/UT Operation one of the input channels provides pulses which are counted over the known time interval between start and stop pulses from clock-pulse generator. With the proper placement of a decimal point the lighted DCU's indicate events or cycles per second.
2. Under PERIOD or TIM Operation pulses of known frequency from the clock-pulse generator are counted over an unknown interval between start and stop pulses from one or both of the input channels. Since the clock-pulse frequency is equal to the 1MC or 100KC oscillator frequency divided by a power of 10, the time measurement appears directly in decimal fractions of a second.
3. Under A/B Operation pulses from one of the input channels are counted between start and stop pulses from the other channel. If the events represented by the pulses are cycles of input signal waves, the DCU's indicate the number of cycles at one input which occur during one cycle at the other INPUT or, in other words, a frequency ratio.

During all "times ten" (x 10) operations the start-stop pulse frequency is divided by 10 so that the counting period is multiplied by 10 and the reading is 10 times as large. Figures 4a thru f show the selection of pulse sources for each operation.

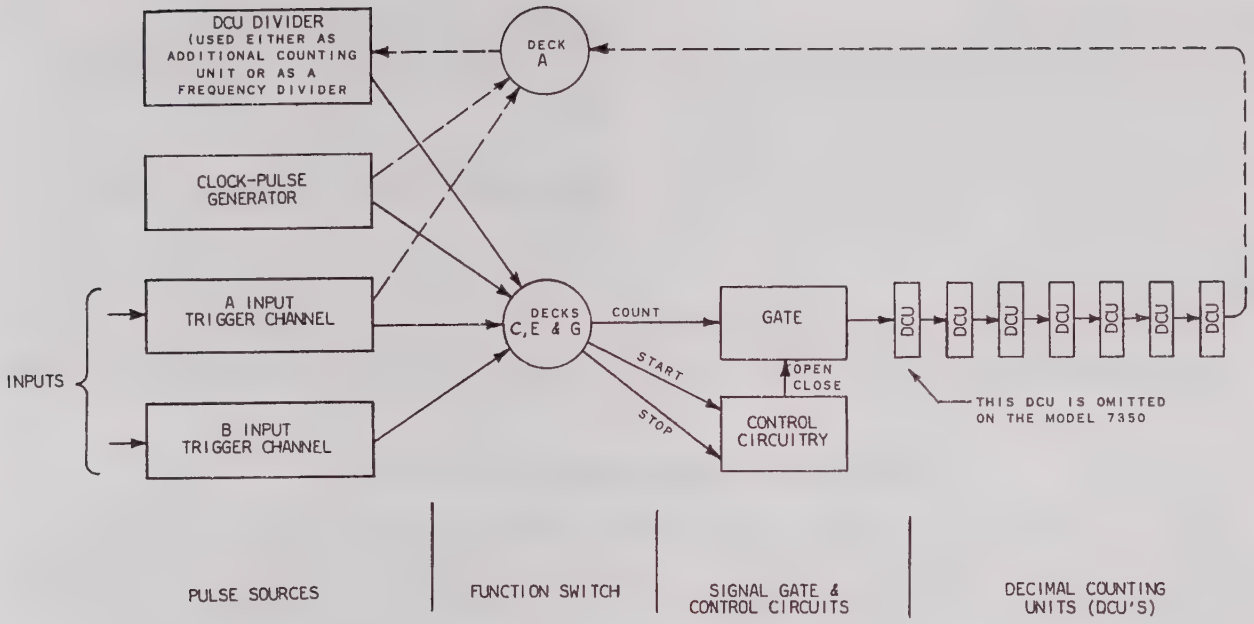


Figure 2 Signal Paths between Major Components

OPERATING CONTROL & CONNECTOR FUNCTIONS

CONTROLS

POWER switch

Turns power on and off.

FUNCTION switch

1. Interconnects major components to perform the measurement indicated by the pointer.
2. Used to manually control COUNT and SCAN operations.

TIME-SECONDS switch

Selects time interval for events-per-unit-time & TEST measurements and unit of time measurement for PERIOD and TIM measurements.

ATTENUATION controls

Attenuates the signal at the adjacent INPUT jack by the voltage factor to which the pointer is set. When turned to the AC side only the a-c component of the input signal reaches the input trigger channel.

TRIGGER VOLTAGE Controls

Selects the instantaneous voltage at which the attenuated signal triggers the adjacent input channel.

SLOPE switches

Selects the slope of the input voltage waveform which triggers the input channel pulse used to operate the gate and control circuitry. The input channel which each SLOPE Switch affects varies with the position of the FUNCTION switch. See "PERFORMING SPECIFIC OPERATIONS" to determine the function of the SLOPE switches at a particular position of the FUNCTION switch.

DISPLAY Time Control

Determines how long the instrument holds a reading before resetting and beginning another count. When this control is turned to the extreme clockwise position, the instrument will hold a reading until the manual RESET button is depressed.

Manual RESET Button

Removes the previous reading and readies the instrument to begin another counting period.

INPUT Trigger Channel Jacks

Inputs to the two Input Trigger Channels

FREQUENCY Jack (Chassis Rear)

When the EXT-INT switch is at INTernal, the 1MC oscillator signal is available here. When the switch is at EXTernal, the external reference frequency must be connected to this jack.

COUNTER INPUT ADJUSTMENTS

INPUT ADJUSTMENTS WHEN COUNTING CYCLES OF A SINE-WAVE SIGNAL

In the common case in which the input approximates a sine-wave signal having a frequency between 10 cps and 1.15 MC, and when the object is merely to generate one pulse for each cycle without regard for the precise time at which a pulse occurs, the ATTENUATION and TRIGGER VOLTAGE controls may be set as follows:

1. Couple the input signal to the B INPUT jack. Input sensitivity is 100 mv rms (0.3 volts peak-to-peak). Input impedance is 10 megohms.
2. Place FUNCTION switch at COUNT and press manual reset button. (SLOPE switches may be in any position.)
3. Rotate the TRIGGER VOLTAGE control slowly from one extreme to the other while the ATTENUATION control is at each of the three positions on the AC side (1, 10 & 100). Notice that the instrument will count steadily over a certain arc of TRIGGER VOLTAGE positions for each ATTENUATION setting. Choose the highest ATTENUATION position at which counting will continue over an arc of at least 45 degrees rotation of the TRIGGER VOLTAGE control.
4. Position the TRIGGER VOLTAGE control at the center of the arc over which counting occurs.

EFFECT OF INPUT CONTROLS

Figure 3a is a block diagram of an input trigger channel.

The impedance at the INPUT jack is 10 megohms in parallel with 40 micromicrofarads. This impedance may be reduced to match the source or to avoid capacitive pickup by attaching a "T" connector to the jack and adding resistors or capacitors in parallel. The input sensitivity is equal to 0.3 volts peak-to-peak times the factor to which the ATTENUATION control is set. The input circuitry will withstand a signal as strong as 500 volts peak-to-ground without damage.

The attenuator divides the voltage introduced at the INPUT jack by the factor indicated by the ATTENUATION control. When the control points to a factor on the side labelled "DC", the total INPUT signal is attenuated and passed on. When the control points to a factor on the side labelled "AC", the d-c component is removed and only the a-c component is attenuated and passed on. Frequencies as low as 1 cps will be passed in the "AC" positions.

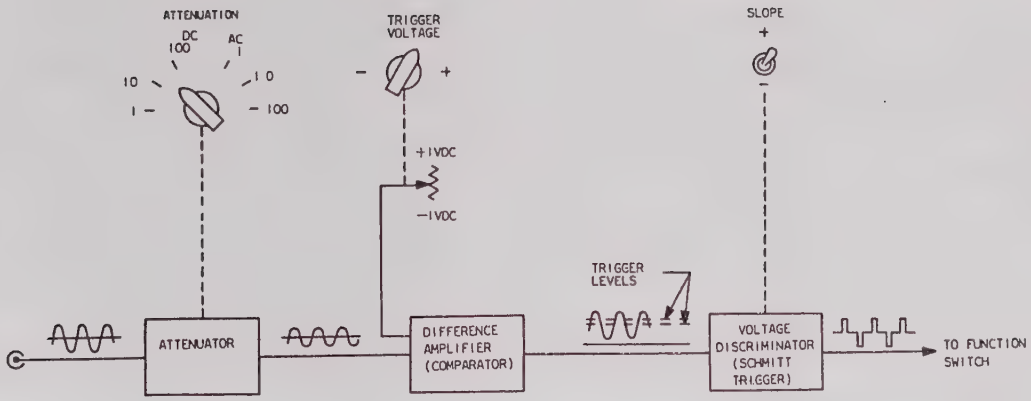


Figure 3a

Figure 3b shows how the varying voltage of the attenuated signal triggers channel output pulses. A pulse is produced each time the instantaneous voltage of the attenuated signal passes through the "positive-going trigger voltage" starting from a value more negative than the "negative-going trigger voltage". Another pulse is produced each time the instantaneous attenuated voltage passes through the "negative-going trigger voltage" starting from a value more positive than the "positive-going trigger voltage". When the SLOPE switch is at "+", only pulses triggered by positive-going voltage excursions affect the succeeding circuitry. With the SLOPE switch at "-", only pulses triggered by negative-going excursions are effective.

The two trigger voltage levels (positive-going and negative-going) are always separated by 0.3 volts, the effective hysteresis. Because a voltage excursion must travel through both levels to trigger a pulse, the sensitivity of the channel to the attenuated signal is 0.3 volts peak-to-peak.

The trigger voltage levels of either input channel may be raised or lowered simultaneously (maintaining 0.3-volt separation) when the TRIGGER VOLTAGE control for that channel is varied. This control will vary the levels from roughly -1 volt to +1 volt. Referring to figure 3, notice that the TRIGGER VOLTAGE control actually raises or lowers the d-c level of the input to the voltage discriminator. However, this action has the effect of raising or lowering the trigger voltage levels at the input to the difference amplifier.

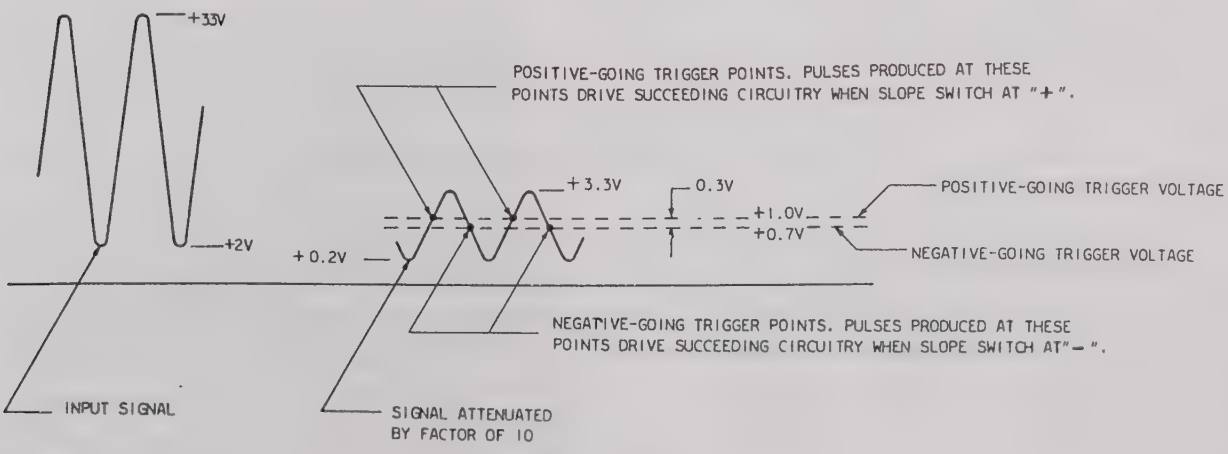

+33V
+2V
+0.2V
POSITIVE-GOING TRIGGER POINTS. PULSES PRODUCED AT THESE POINTS DRIVE SUCCEEDING CIRCUITRY WHEN SLOPE SWITCH AT "+".
+3.3V
0.3V
+1.0V
+0.7V
POSITIVE-GOING TRIGGER VOLTAGE
NEGATIVE-GOING TRIGGER VOLTAGE
NEGATIVE-GOING TRIGGER POINTS. PULSES PRODUCED AT THESE POINTS DRIVE SUCCEEDING CIRCUITRY WHEN SLOPE SWITCH AT "–".
INPUT SIGNAL
SIGNAL ATTENUATED BY FACTOR OF 10

Figure 3b

The purpose of the input trigger channel is to produce a reliable pulse output representing that part of the input signal in which the operator is interested. This is achieved only when the ATTENUATION and TRIGGER VOLTAGE controls are properly adjusted. Before attempting to adjust the controls, it is best to visualize the input waveform, noting the shape, a-c amplitude and d-c level. The effect of various control settings is then relatively easy to calculate. Referring to figure 3, notice that:

1. If the attenuated signal is small peak-to-peak, the trigger voltage levels may be set so high or so low that no pulses are produced. In figure 3, for example, if the "positive-going trigger voltage" were set at -0.5 volts (thus placing the "negative-going trigger voltage" at -0.8 volts), the attenuated signal with peaks at +0.2 and +3.3 volts would not intersect either trigger voltage level.
2. If the attenuated voltage variations ride on a d-c level, they may not come within the trigger voltage range. In figure 3, again, if the input signal were not attenuated (or a-c coupled) the negative peak at +2 volts would not intersect any possible trigger voltage level.
3. Modulation or variations in the d-c level of the attenuated signal are least likely to subtract pulses if the trigger voltages are set about halfway between the peaks of the signal.
4. Extraneous signals (noise, hum, modulation, drift, etc.) have the least effect on the time at which a pulse occurs when the channel triggers on a steep slope of the waveform.
5. Noise below 0.3 volts peak-to-peak will not trigger extraneous pulses. Consequently, attenuating a signal carrying a given percentage of noise may eliminate the effect of the noise. For example, 1 volt peak-to-peak noise on a 6 volt peak-to-peak signal will trigger extraneous pulses. If the signal is attenuated by a factor of 10, the resulting 0.6 volt p-p signal will still trigger desired pulses dependably, while the resulting 0.1 volt p-p noise is well below the sensitivity of the channel.
6. Attenuating the input signal

   (a) Reduces the slope at all points
   (b) Shifts the a-c component nearer ground if it rides on a d-c level.
   (c) Increases the minimum peak-to-peak variations necessary to trigger pulses (measured at the INPUT jack) from 0.3 volts to 3 or 30 volts
   (d) Increases the range of possible trigger voltage setting on the input signal from ±1 volt to ± 10 volts or ± 100 volts.

Adjustment of ATTENUATION and TRIGGER VOLTAGE controls should be made keeping the above characteristics in mind. When using any regular periodic input signal, consistent E/UT or PERIOD readings are a good indication that the controls are properly adjusted.

The point on an input waveform where the input channel triggers may be seen on an oscilloscope. Observe the input of the voltage discriminator in the input channel used (V303, Pin 2). The waveform which appears is the amplified input signal together with small "notches" created on each slope as the channel triggers. Rotating the TRIGGER VOLTAGE control will cause these notches to move up and down the waveform. See "Typical Waveforms" for a sample display.

The trigger voltage may be set at a precise value by applying a d-c voltage of that value at the INPUT jack, setting the ATTENUATION control at an appropriate factor on the DC side and rotating the TRIGGER VOLTAGE control to the point where an output pulse is produced. With no input voltage the INPUT jack lies at ground and a pulse will be produced at ground level. Output pulses from the B channel may be seen being counted when the FUNCTION switch is at E/UT. Pulses from the A channel are counted on the A/B position.

Some information about the position of the trigger voltage relative to the signal may be extracted from the instrument itself. The trigger voltage may be varied between the positive and negative peaks of an attenuated signal whose peaks lie within the range -1 to +1 volts. As the trigger voltage pass beyond the signal peaks the pulse output of the channel will cease and these positions of the control may be noted.

PERFORMING SPECIFIC OPERATIONS

MEASURING FREQUENCY

The frequency of a regular sine-wave signal can be measured either directly under E/UT or E/UT x 10 Operation or indirectly by measuring the period of the signal and calculating the frequency. The direct method is simpler and will ordinarily be used except when measuring a low frequency. signal with extreme accuracy. See the "ACCURACY" section of this manual for the accuracy limitations of events-per-unit-time operation.

NOTE: At "X10" positions of the function switch, the DCU at the far left does not function in the counting chain; therefore, disregard its indication.

TEST Operation

To put the instrument in operation connect the power cord and place the POWER switch in the position which lights the green indicator above it. After a two minute warm-up, test the instrument for proper operation:

1. Turn DISPLAY Time to a point near the extreme counter -clockwise position to obtain a short display time and automatic operation.
2. Turn FUNCTION switch to TEST.
3. Rotate TIME switch to each position starting with the 10-5 seconds setting on the Model 7360 or the 10^{-4} seconds setting on the Model 7350. In either case this should give a reading of 10. As the switch is turned clockwise, other settings should read successively 100, 1000 or 999, 10, 000 or 9, 999, 100, 000 or 99, 999 and (on the Model 7360 only) 1, 000, 000 or 999, 999.

Note that the DISPLAY time is infinite at the extreme clockwise position of the control. In this position, the instrument must be reset manually.

E/UT (Events-Per-Unit-Time) Operation

At the E/UT position of the FUNCTION switch the unit counts the input to the B Channel between start and stop signals separated by a precise time interval. This setting may be used to measure the frequency of a signal or the number of events occuring within a selected time interval. The major components are connected as diagramed in Figure 4a.

To make a measurement proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to the E/UT position. In this position the SLOPE

switch on the B-START-E/UT-PERIOD side of panel determines the polarity of the voltage excursion which triggers count pulses. It may be at either position.

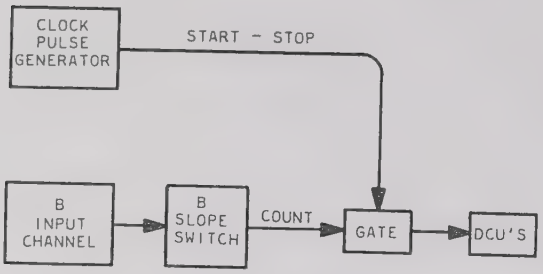


Figure 4a

3. Set the TIME switch at the time interval over which events are to be counted.
4. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.
5. To obtain a reading in events per second, divide the reading on the lighted DCU's by the number to which the TIME switch is set.

E/UT x 10 Operation

At the E/UT x 10 position of the FUNCTION switch the unit counts every cycle of the input to the B channel between stop and start signals separated by 10 times the interval indicated by the TIME switch. This setting may be used to obtain a 10-second time interval. Counting over the 10-second period produces more accurate frequency measurements than may be made using shorter time intervals. The major components are connected as diagramed in Figure 4a except that the output of the Clock-Pulse Generator is fed through the DCU Divider before reaching the Gate. To make a measurement proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate FUNCTION switch to the E/UT x 10 position.
3. Set the TIME switch. At this position of the FUNCTION switch the interval during which events are counted is 10 times that indicated by the TIME switch.
4. Adjust the DISPLAY TIME control for a convenient reading.
5. To obtain a reading in events per second divide the reading on the DCU's by 10 times the factor indicated by the TIME switch.

SCAN Operation

The interval during which events are counted may be extended to any multiple of the 1 or 10-second counting periods. Consider the total counting interval desired as N counting periods. Then proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Turn DISPLAY TIME control fully clockwise.
3. Place FUNCTION switch at E/UT x 10.
4. Select a one or ten-second counting period. If the FUNCTION switch is at E/UT x 10 turn the TIME switch to 1 to obtain a 10-second period and to 10^{-1} to obtain a one-second period.
5. Press the RESET button. Within 1 second the instrument will begin a normal counting period.
6. Before the end of this period (one or 10 seconds as the case may be) turn the FUNCTION switch to the SCAN position and begin timing N minus 1 counting periods with a stopwatch.
7. At the end of N minus 1 periods turn the FUNCTION switch back to E/UT x 10.
8. When the instrument stops counting, read the count. Ignore the digit (if any) appearing on the DCU farthest to the left. This DCU has not been counting continuously during the extended interval.

A/B Operation

At the A/B position of the FUNCTION switch the unit counts the signal at the A INPUT between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the ratio of two frequencies or to count the number of events occurring while the B INPUT is above or below a given voltage level. The major components are connected as diagramed in Figure 4b.

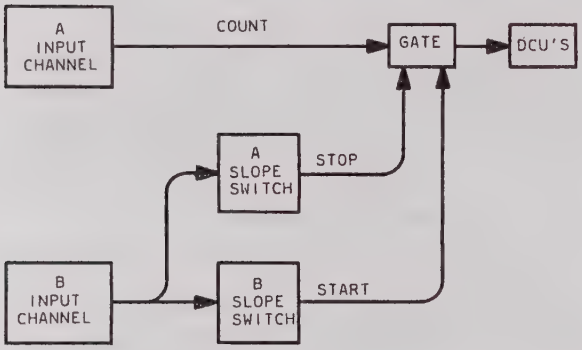


Figure 4b

To make a measurement proceed as follows:

1. Connect the higher frequency to the A INPUT jack and the lower frequency to the B INPUT jack. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to A/B. In this position the SLOPE switch on the B side of the panel determines the polarity of the voltage excursion which begins count of the A input. The other SLOPE switch sets the polarity of that which ends the counting period.
3. Therefore,
   (a) When measuring the ratio of two frequencies set both SLOPE switches "+" or both to "-".
   (b) When counting the A input during the period the B input voltage remains above a certain level, set the SLOPE switch on the B side to "+" and the other to "-".
   (c) When counting the A input during the period the B input voltage remains below a certain level, set the SLOPE switch on the B side to "-" and the other to "+".
4. Adjust the DISPLAY TIME control to a position at which the count on the lighted DCU's may be read conveniently.
5. Take a reading. When measuring a frequency ratio the DCU's indicate the ratio of the A input frequency to the B input frequency.

A/B x 10 Operation

At the A/B x 10 position of the FUNCTION switch the unit counts the signal at the A INPUT between a voltage excursion through a selected level at the B INPUT and the tenth following excursion. This setting will measure a frequency ratio more accurately than the A/B operation. The major components are connected as diagramed in Figure 4c.

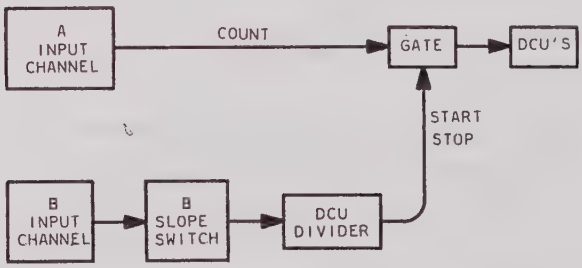


Figure 4c

To make a measurement proceed as follows:

1. Connect the higher frequency to the A INPUT jack and the lower frequency to the B INPUT jack. (See "COUNTER INPUT ADJUSTMENT" above).
2. Rotate the FUNCTION switch to A/B x 10. In this position the B SLOPE switch determines the polarity of the voltage excursion which begins and ends counting.
3. For greatest accuracy set this SLOPE switch on the steeper slope of the B input
4. Adjust the DISPLAY TIME control to a position at which the count on the lighted DCU's may be read conveniently.

5. Divide the reading by 10 to obtain the ratio of the A INPUT frequency to the B INPUT frequency.

TIM (Time-Interval-Meter) Operation

At TIM position of the FUNCTION switch the unit measures the time between a voltage excursion through a selected level at the B (START) INPUT and a voltage excursion through an independently chosen level at the A (STOP) INPUT. The major components are connected as diagramed in Figure 4d.

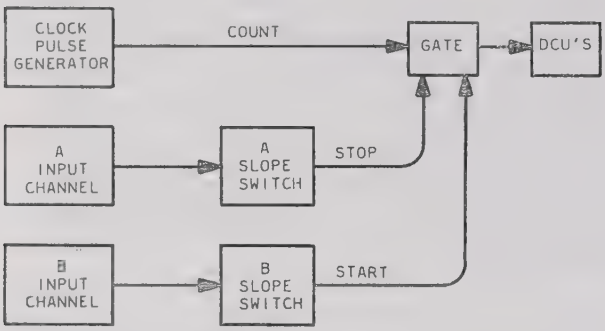


Figure 4d

To make a measurement proceed as follows:

1. Connect the start signal to the START INPUT and the stop signal to the STOP INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to TIM. In this position the B SLOPE selects the polarity of the voltage excursion which begins the timing period. The A SLOPE switch selects the polarity of that which ends the timing period.
3. Rotate the TIME switch to the desired unit of time measurement. For example, at the 10^{-4} position the time measurement appears in ten-thousandths of a second. The smaller the time unit chosen, the more accurate the reading.
4. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.
5. To obtain a reading in seconds, multiply the count on the DCU's by the factor to which the TIME switch is set.

PERIOD Operation

At the PER position of the FUNCTION switch the unit measures the time interval between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the period of a wave or the width of a pulse. The major components are connected as in Figure 4e.

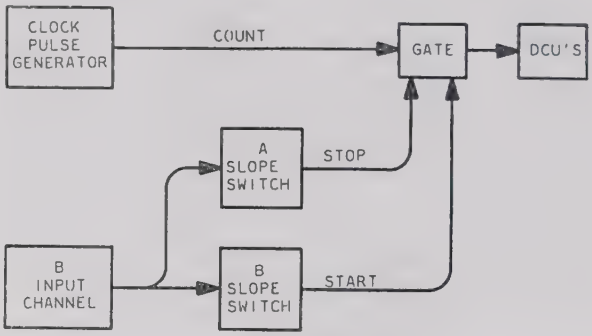


Figure 4e

To make a measurement proceed as follows:

1. Connect the wave or pulse source to the B (PERIOD) INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to PERIOD. At this position the B SLOPE switch selects the polarity of the voltage excursion which begins the timing period. The A SLOPE switch selects the polarity of that which ends the timing period.
3. Therefore,
   (a) When measuring the period of a wave, set both SLOPE switches to "+" or both to "-".
   (b) When measuring the width of a positive pulse, set the B SLOPE switch to "+" and the A SLOPE switch to "-".
   (c) When measuring a negative pulse, set the B SLOPE switch to "-" and the A SLOPE switch to "+",
4. Follow steps 3, 4 & 5 under "TIM Operation".

PERIOD x 10 Operation

The unit measures the time interval between a voltage excursion through a selected level at the B INPUT and the tenth following excursion. This setting will measure the period of a wave more accurately than the PERIOD operation. The major components are connected as diagramed in Figure 4f.

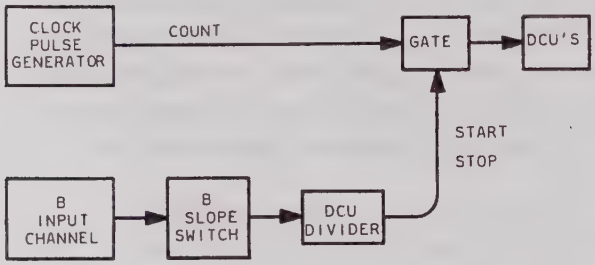


Figure 4f

To make a measurement proceed as follows:

1. Connect the wave source to the B (PERIOD) INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to PERIOD x 10. The B SLOPE switch selects the polarity of both start and stop voltage excursions.
3., 4 & 5. Follow steps 3, 4 & 5 under "TIM Operation".
6. Divide the reading by 10 to obtain the length of one period.

COUNT Operation

The unit counts the input to the B channel during the period the FUNCTION switch is in the COUNT Position.

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Turn FUNCTION switch to OFF.
3. Depress manual RESET button.
4. Twist FUNCTION switch to COUNT to begin counting.
5. Twist FUNCTION switch to OFF to stop counting.

GATE Operation

This operation is a variation of TIM operation. Pulses generated by an external signal are substituted for internal clock pulses. The instrument counts cycles of the substituted signal between a voltage excursion through a selected level as the B (START) INPUT and a voltage excursion through an independently chosen level at the A (STOP) INPUT.

The substituted signal must have an amplitude of 5 volts rms into a 7K load. Its frequency may be as high as 100KC in the case of the Model 7350 or as high as 1MC in the case of the Model 7360. Couple the signal to the FREQ. jack at the rear of the counter and place the EXT-INT switch at EXT.

NOTE: The .01 μf capacitor (C401) connected between the FREQ. jack and the input circuit used for this operation is not large enough to pass frequencies lower than 1 KC. If the external signal frequency is lower than 1 KC, jumper this capacitor and connect a larger capacitor between the signal source and the FREQ. jack.

Rotate the TIME switch to 10^{-5} on the Model 7350 or to 10^{-6} on the Model 7360. Place the FUNCTION switch at TIM. Adjust the START and STOP input channels as described under "INPUT ADJUSTMENTS". See "TIM Operation" to learn how the SLOPE switches operate on these channels. The shaper stage of the clock pulse generator is used as the input trigger channel for the signal introduced at the FREQ. jack. Adjust the input trigger voltage of this channel with the SHAPER LEVEL control located on the top side of the counter chassis. Rotate this control to find the limits of the range in which the instruments counts. Set the control at the center of this range.

USING AN EXTERNAL REFERENCE FREQUENCY

An external reference frequency may be substituted for the internal oscillator signal. Introduce the external signal as described under "GATE Operation," but place the TIME switch at a position which produces a clock pulse frequency equal to the reference frequency divided by the desired power of 10.

REMOTE CONTROL OF OPERATING CYCLE

The counter can be controlled from a remote location so that it will not reset and begin another count until desired. Set the DISPLAY time control at a minimum and string a lead from the remote location to Pin 40 of the DIGITAL RECORDER socket. As long as this lead is grounded the counter will not reset. If a count is complete, then within 40 milliseconds after the lead is ungrounded the counter will have reset and be ready to start counting when a start pulse appears. As soon as the counter has reset, the lead may be grounded again or left ungrounded. It will not affect the operating cycle until the time arrives for the next automatic reset. At that time it must be grounded again to prevent reset.

ACCURACY

Measurements are subject to four important sources of error.

1. Counts missed or added as the Gate opens and closes.
2. Clock signal inaccuracy.
3. Errors in the time a start or stop pulse is triggered.
4. Counts missed because they occur during the resolution time of the counting circuits.

1.

Pulses which occur simultaneously with the opening or closing of the Gate may or may not be counted. This causes all measurements to vary plus or minus one count. The following equation defines the possible error introduced.

$$(1)\ \text{Max. \% error} = \frac{1}{\text{Count}} \times 100.$$

Notice that measurements set up to yield the highest count indication will be most accurate.

The frequency of a sine wave signal can be measured directly by counting events-per-unit-time or indirectly by measuring the length of one period and calculating the frequency. Higher frequencies yield the highest count indication when measured directly, that is, using the E/UT or E/UT x 10 function. Lower frequencies produce the highest indication when rapid time signals are counted over one or ten periods - that is, using the PERIOD or PERIOD x 10 function.

On the Model 7360 frequencies above 1KC produce the highest count indication when measured using the E/UT x 10 function and a 10-second time interval; frequencies below 1KC yield the highest count when measured with the PERIOD x 10 function and a 1 μsecond unit of time measurement. The accuracy achieved using alternative functions at various frequencies is graphically illustrated in Figure 6. Note that the curves for E/PUT x 10 (10-second interval) and PERIOD x 10 (1 μsec time unit) cross at 1KC. This frequency cannot be measured with a possible error less than .01%. Frequencies above and below may be measured with greater accuracy.

The smallest unit of time available on the Model 7350 is 10 μseconds. Lower frequencies are most accurately measured using the PERIOD X 10 function and this time unit. Notice on Figure 6 that this curve crosses the EPUT X 10 curve at 316 cps. Therefore on the Model 7350 frequencies above 316 cps are most accurately measured using EPUT x 10 and a 10-second time interval whereas frequencies below 316 cps are best measured using the PERIOD x 10 function and the 10 μsecond unit of time. 316 cps cannot be measured with a possible error less than .03%,

but lower and higher frequencies may be measured more accurately.

2. All measurements requiring a time signal (i.e. all measurements except A/B, A/B x 10 and COUNT) are subject to an additional error introduced by variations in the oscillator frequency. The oscillator frequency in the Model 7360 is stable to 2 parts in 10^7 per day and 3 parts in 10^7 per week, so it can cause a maximum error of only .00002%. The oscillator in Model 7350 is stable to 1 part in 10^6 per day. It causes a maximum error of .0001%.

3. Measurements using a external signal to trigger start and stop pulses (i.e. PERIOD, PERIOD x 10, TIM, A/B and A/B x 10) may be subject to a further error caused by pulses which are triggered too soon or too late. Refer to Figure 5 which illustrates what occurs during a simple period measurement.

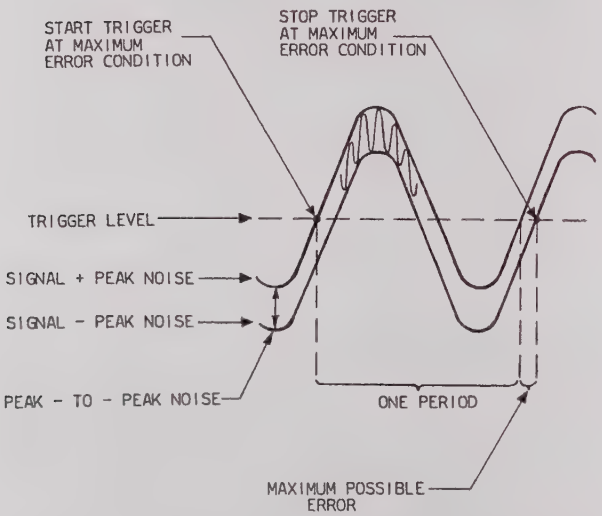

START TRIGGER AT MAXIMUM ERROR CONDITION
STOP TRIGGER AT MAXIMUM ERROR CONDITION
TRIGGER LEVEL
SIGNAL + PEAK NOISE
SIGNAL - PEAK NOISE
PEAK - TO - PEAK NOISE
ONE PERIOD
MAXIMUM POSSIBLE ERROR

Figure 5 Effect of Noise on Accuracy of Period Measurements

Consider the total signal as an ideal signal intended to trigger the input channel plus a noise signal. The noise voltages added or subtracted from the ideal signal may trigger a pulse before or after the instant at which counting should begin or end. The maximum error in the time of triggering will be proportional to the noise amplitude and inversely proportional to the slope of the ideal signal at the trigger level. Expressed mathematically,

$$(2)\ t\ (\text{secs}) = \frac{V_n\ (\text{volts})}{S\ (\text{volts/sec})}$$

where t = Max. error in trigger time

V_n = peak-to-peak noise

S = slope of ideal signal at trigger level

The total noise (V_n) is equal to that carried by the input signal after attenuation plus that internally generated by the input channel. The internal noise (which takes the form of amplifier drift, trigger level jitter, line frequency pick-up, etc) is not more than 300 microvolts. Note that as the amplitude of of the input signal is increased, S in equation (2) becomes larger and the internal noise causes less error.

The percentage error may be calculated by dividing the error in trigger time by the counting period and multiplying by 100. In the common case of a period measurement of a sine wave triggering at its zero crossover value:

$$(3)\ \text{Max. \% error} = \frac{V_n\ (\text{volts})}{V_s\ (\text{volts}) \times \pi} \times 100$$

where V_n = peak-to-peak noise

V_s = peak-to-peak signal

The maximum percent error of a PERIOD x 10 measurement is one-tenth the value given in equation (3).

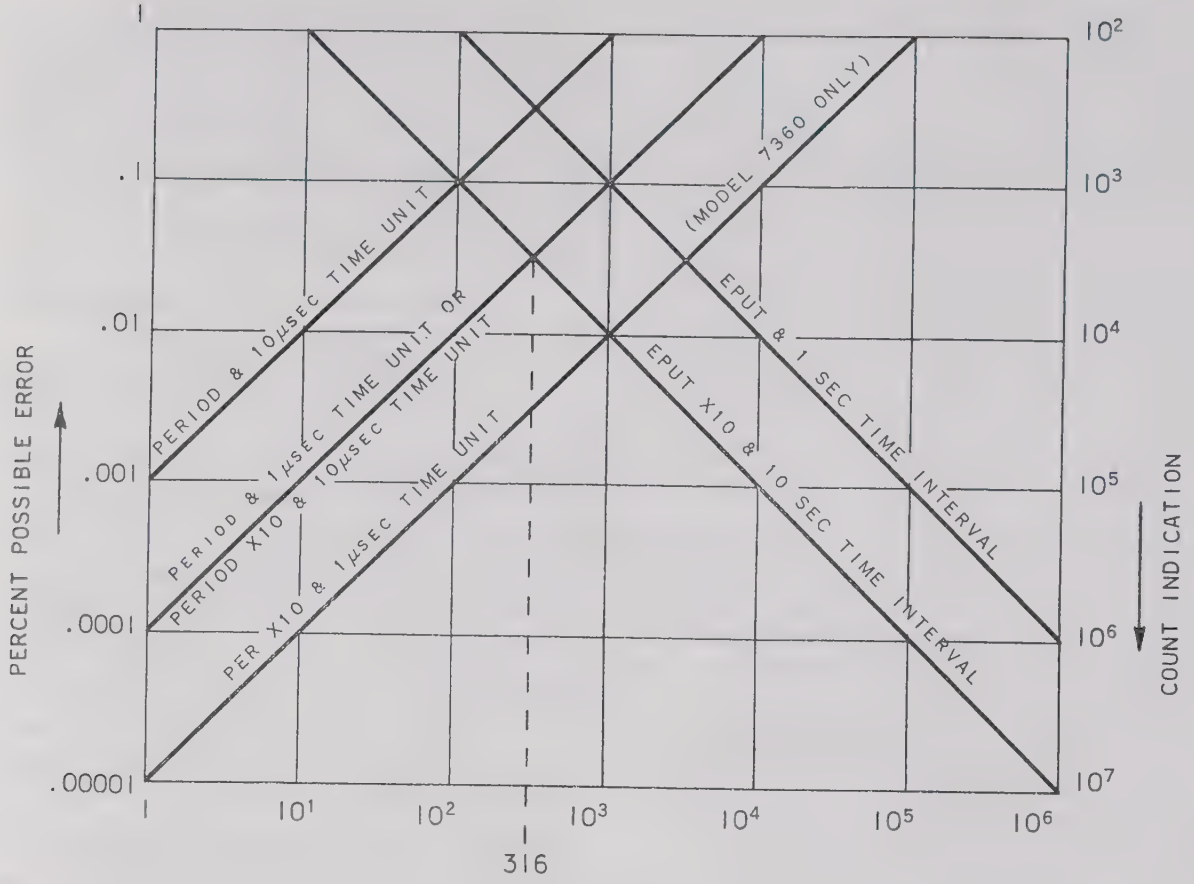
The total error due to the three causes mentioned above is equal to the sum of the separate errors.

Total Max. percent error equals:

$$\frac{100}{\text{Count Indication}} + \begin{matrix}.00002\ (7360) \\ \text{or} \\ .0001\ (7350)\end{matrix} + \text{Percent error due to noise}$$

$.00002\ (7360)$ or $.0001\ (7350)$ ↓ If E/UT, E/UT x 10, PERIOD, PERIOD x 10

Percent error due to noise ↓ If PERIOD, PERIOD x 10, TIM, A/B or A/B x 10



NOTE: THE 1μSECOND TIME UNIT IS NOT AVAILABLE ON THE MODEL 7350

Figure 6 Error due to ± 1 Count Limitation

4. Another source of error becomes important when random events are counted. One such event may occur immediately after another, before the counting circuits are fully recovered and prepared to register it. The second event will not only fail to cause a count but its effect on the circuitry may cause a third event to fail to register also. Formulae for calculating the counting error due to this effect may be found in "Application of Probability Theory to Nuclear Particle Detection", L. J. Rainwater and C. S. Wu, Nucleonics, October 1947. The minimum time which must elapse between events if both are to be counted is called resolution time of the instrument. The Model 7360 has a resolution time of .8 μseconds. The Model 7350 has a resolution time of 5 μseconds.

AUXILIARY CONNECTORS

DIGITAL RECORDER Jack. This multi-terminal socket, wired to the readout lines of each DCU, makes available 1-2-4 binary-coded signals for use with such auxiliary equipment as printers, in-line display units, and data converters. One of the tables below gives the binary code generated by the DCU's for each decimal digit registered. "0" means an output level of about -15 volts with respect to ground; "1", a level at ground or slightly positive with respect to ground. The other table lists the pin connections to each DCU.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1
No Digit	0	0	1	0

	PIN NO. ON DIGITAL RECORDER SOCKET			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
Highest order digit read*	Pin 4	Pin 3	Pin 2	Pin 1
2nd highest order digit	8	7	6	5
3rd highest order digit	12	11	10	9
4th highest order digit	16	15	14	13
5th highest order digit	20	19	18	17
6th highest order digit**	24	23	22	21

* On instruments featuring "times ten" positions of the FUNCTION switch no read-out pins are provided for the left-most DCU, which displays the highest order digit during some measurements. On these instruments the highest order digit represented by a 4-line code is in the front-panel column second from left

** On instruments containing only five read-out DCU's pins 21 thru 24 are permanently wired to produce the "no digit" code which is "0010"

Pin 39 carries a control signal from the counter. This pin is negative during the display period and positive from reset until the end of the next counting period. Source impedance at pin 39 is nominally 250 K shunted by 100 $\mu\mu$f.

Pin 40 is the "inhibit reset" line. When this pin is grounded the counter cannot reset.

Pins 26, 30, (7350 only), 31, 32 and 38 are grounded. Pins 25, 27 and 28 are connected to the -35 volt supply. Pin 29 and pins 33 through 37 are not used.

TIME Jack. The output signal of the clock-pulse generator is available at this jack. The signal consists of positive pulses 2.0 volts in amplitude. The positive transients are accurately spaced at the interval indicated by TIME-SECONDS switch. These transients are recommended for external use as a clock signal. The negative transients occur at the same frequency but are not so accurately spaced. The output impedance is 330 ohms.

FREQ Jack. A sine-wave signal at the oscillator frequency is available at this jack when the EXT-INT switch is at INT. The signal is 10 volts peak-to-peak out of 3000 ohms. When the EXT-INT switch is at EXT., an external signal can be introduced at this jack to substitute for the oscillator signal as described under "Using an External Reference Frequency".

SCOPE Jack. This jack is connected thru 220 K to the suppressor grid circuit of the gate tube. The voltage at the jack is about -10 volts with respect to ground when the gate is open and about -40 volts when the gate is closed. If the waveform of a signal which generates start-stop pulses is displayed on an oscilloscope, the signal at the SCOPE jack (after suitable conversion) may be used to blank the scope during the period the gate is closed. The scope will then display the portion of the wave form whose duration is being measured.

3 Circuit description

NOTE:
It is intended that the reader refer frequently to relevant schematic diagrams while reading the material in this section. The Decimal counting Units are described in an appendix.

GATE & CONTROL CIRCUITRY

The Gate and control Circuitry receive three pulse inputs from the FUNCTION switch (S201): pulses to be counted, start pulses and stop pulses. Pulses to be counted go from Deck G to the signal grid of the Gate tube (V204). The plate of this tube is coupled to the first of the cascaded DCU's. During the period its suppressor grid is at ground the tube amplifies the grid signal and drives the DCU's. In this state the Gate is "open". When the suppressor grid is below -10 volts, the tube is cut off and the Gate may be considered "closed".

The "open-close" voltages on the Gate tube suppressor grid are generated at the right plate of the Control Binary (V203). V203 is a conventional "flip-flop" circuit. Such a circuit has two stable states: left half conducting, right half cut off; and right half conducting, left half cut off. Input pulses or transients applied at various points on the circuit will trigger it back and forth between the two states. When the right half of V203 is conducting, the right plate is 30 volts negative. A negative start transient from the Start Binary, applied at the left plate of V203 and coupled through C210 to the right grid, triggers V203 to its other stable state. In this state the right half is cut off and the right plate rises above ground permitting the Gate tube to conduct. When a negative stop pulse from Deck E of the FUNCTION switch reaches the left grid of V203 through the diode CR212, V203 is triggered back to the state which holds the Gate closed.

The Start Binary is also a "flip-flop" circuit. It produces a negative start transient at its right plate each time that half begins to conduct. Its left grid is coupled to Deck C of the FUNCTION switch through the diode CR211 and C201. When the left half is conducting a negative start pulse at the grid triggers a change to the other stable state producing the output transient. Further negative pulses at the left grid have no effect since that half is already cut off.

When the instrument is ready to begin a counting period the right half of the Control Binary and the left half of the Start Binary are conducting and the Gate is closed. Negative stop pulses received at the left grid of the Control Binary have no effect since this half is cut off. The following sequence occurs. (Refer to Figures 7 & 8).

Time (1) A start pulse passes through the injection diode CR211 and triggers the Start Binary which in turn triggers the Control Binary to a state which opens the Gate. The DCU's then count and indicate the number of pulses reaching the Gate.

Time (2) A stop pulse triggers the Control Binary to a state which closes the Gate.

At this point, if the instrument is set to operate automatically, the reset circuitry begins to function. The reset control voltage appears at the

junction of CR201 and CR203. Its value is determined by the combined effect of the voltage on the right plate of the Start Binary and that on the right plate of the Gate Control Binary. At the close of a counting period (and only then) both these plates are negative. The resulting negative voltage at the junction is applied to the input grid of the Reset Control through R237 and R239.

This negative voltage biases the left-hand section of the Reset Control tube (V205) to cut off, and the resultant rise in plate potential is coupled to the right-hand grid. Since the right-hand section of V205 operates as a cathode follower, the rise in potential at the grid produces a voltage rise at the cathode. This voltage rise, applied at the junction of resistor R248 and the DISPLAY potentiometer (R247), causes capacitor C216 to discharge through R247. As the capacitor discharges, the potential at the input grid (pin 7) of the Reset Generator (V206) rises.

The Reset Generator is a monostable multivibrator. In its stable state, the right-hand triode section is conducting while the left-hand section is cut off. When the potential on the left-hand grid becomes sufficiently positive, it triggers the Reset Generator to its quasi-stable state (i.e., left side conducting, right side cut off). This occurs at time (3), with the interval between time (2) and time (3) depending on the setting of the DISPLAY control (R247).

At time (3) then, the potential at the left-hand plate of the Reset Generator drops, while that at the right-hand plate goes up. The drop in voltage at the left-hand plate, coupled through capacitors C214 and C215 to the DCU reset lines, produces a negative pulse which resets the DCU's. This same reset pulse also triggers the Start Binary to its initial (left side on) state and makes sure the Control Binary is triggered to its "right side on" state. The rise in voltage at the right-hand plate of the Reset Generator is fed back to the input grid of the Reset Control tube and triggers it to its orignial state (i.e., left side on, right side off). This same voltage rise also puts a reverse bias on diode CR211 so that start pulses can not pass through to trigger the Start Binary.

The Reset Generator remains in its quasi-stable state for 15 milliseconds. At the end of that period, time (4), the Reset Generator jumps back to its stable state (right side on, left side off), and the voltage on the right-hand plate drops. This removes the reverse bias from diode CR211. The Reset Control, however, is not triggered at this time because when the Start Binary is reset, the potential on its right-hand plate goes up and the reset control line is clamped to this higher potential by diode CR201. Thus, the 15 millisecond delay provided by the Reset Generator keeps any start pulses from triggering the Start Binary, to initiate counting, until all reset transients have decayed.

The next start pulse triggers the Start Binary to its "right side on" state which, in turn, triggers the Control Binary to its "left side on" state. To prevent reset action at this time, diode CR203 clamps the reset control line to the relatively high positive potential at the right-hand plate of the Control Binary. The next stop pulse triggers the Control Binary to its "right side on" state, the potential at the right-hand plate drops, and the entire reset process is repeated.

NOTE: When the counter operates with a Berkeley Digital Recorder, the operating cycle is briefly delayed at the end of the counting period (time (2)) until the recorder has received all of the count information from the DCU's (see Figure 9). This delay is produced by a relay in the recorder which grounds the input to the DISPLAY potentiometer (R247) through pin 40 of J202 for the required interval. When the DISPLAY control is turned fully clockwise into its infinity position, the input connection to R247 is broken by switch S204 and automatic reset will not occur. Consequently, the DCU's will hold the registered count until the RESET button is pressed. When this is done, the contacts of switch S205 are shorted, and a positive pulse is applied to the left-hand grid of the Reset Generator. This positive pulse triggers the Reset Generator, and causes it to produce a reset signal just as in automatic operation.

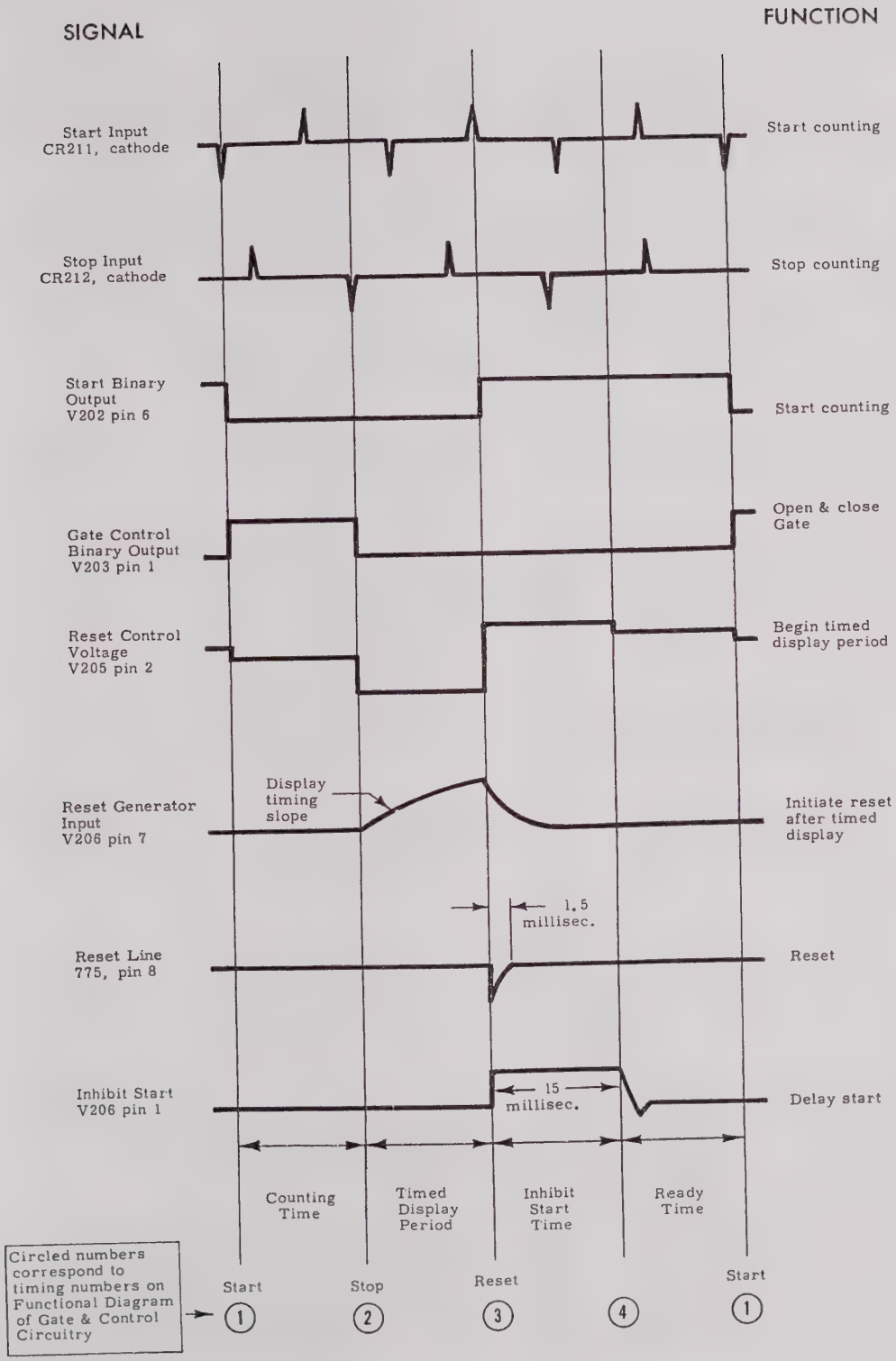
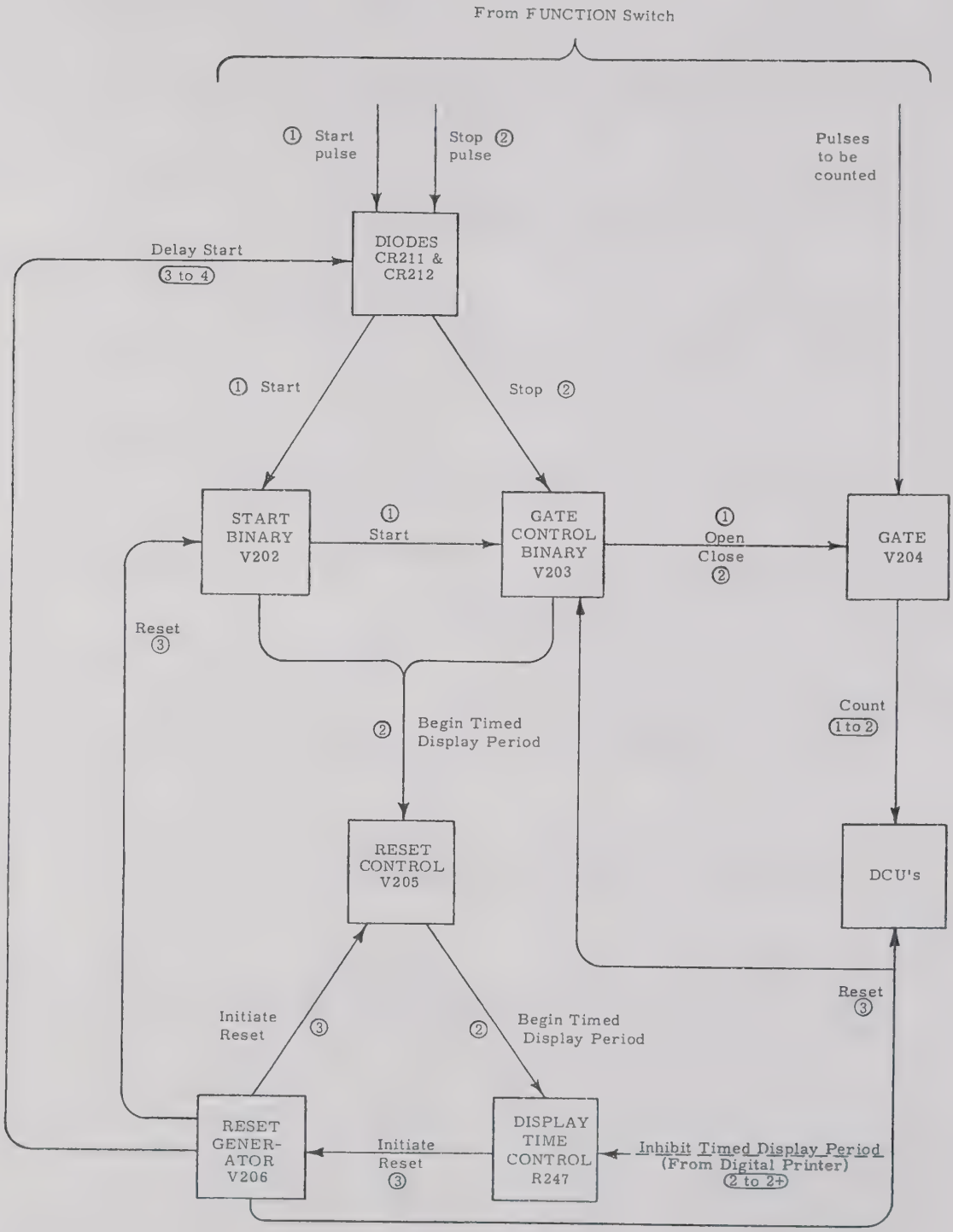


Figure 7 Control Circuit Timing Diagram

WHEN COUNTER IS NOT EQUIPPED WITH DIGITAL PRINTER



NOTE: Circled numbers indicate time of operation as labeled on the Timing Diagrams.

Figure 8 Functional Diagram of Gate and Control Circuitry

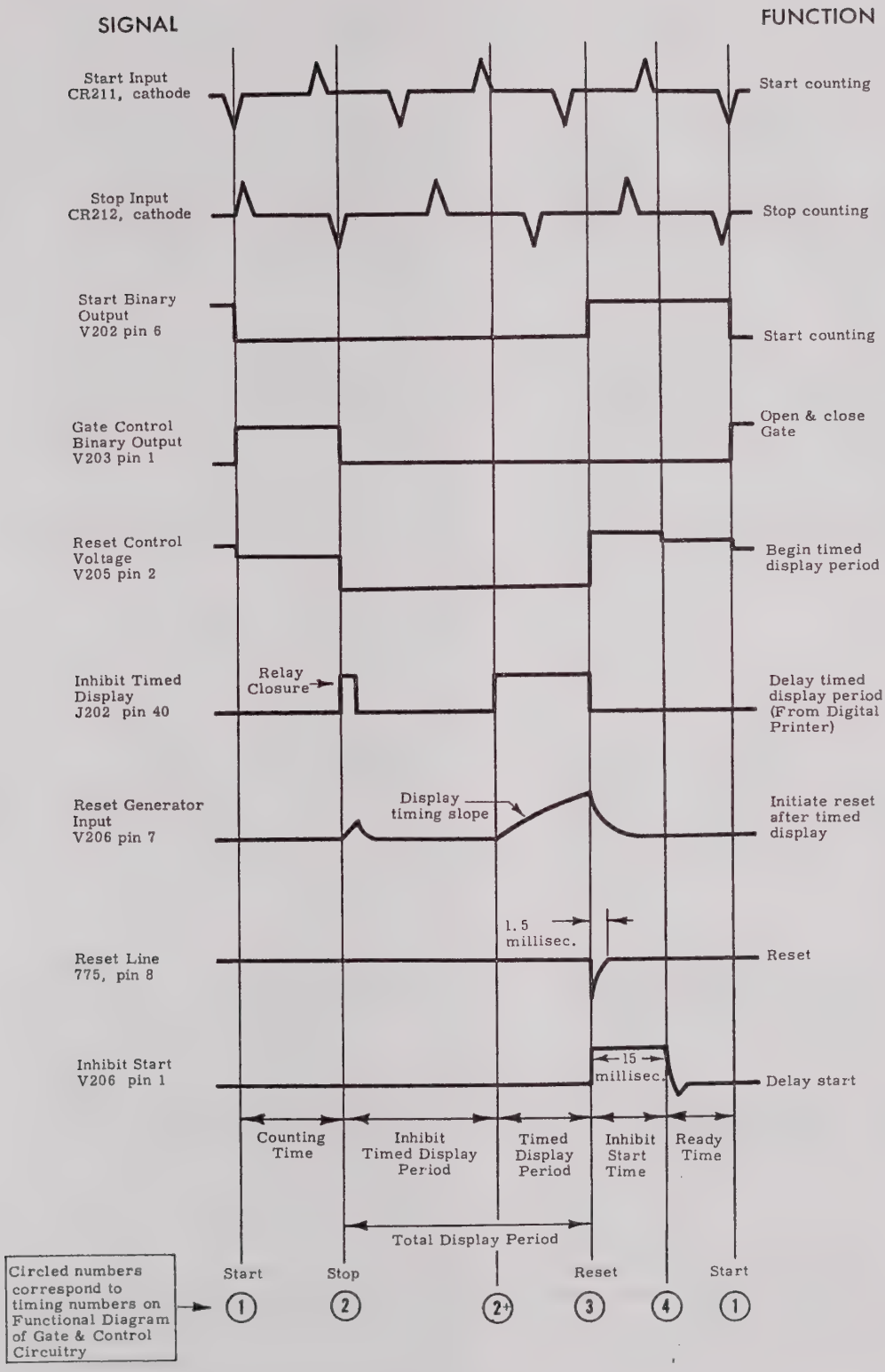


Figure 9 - Control Circuit Timing Diagram

WHEN COUNTER IS EQUIPPED WITH DIGITAL PRINTER

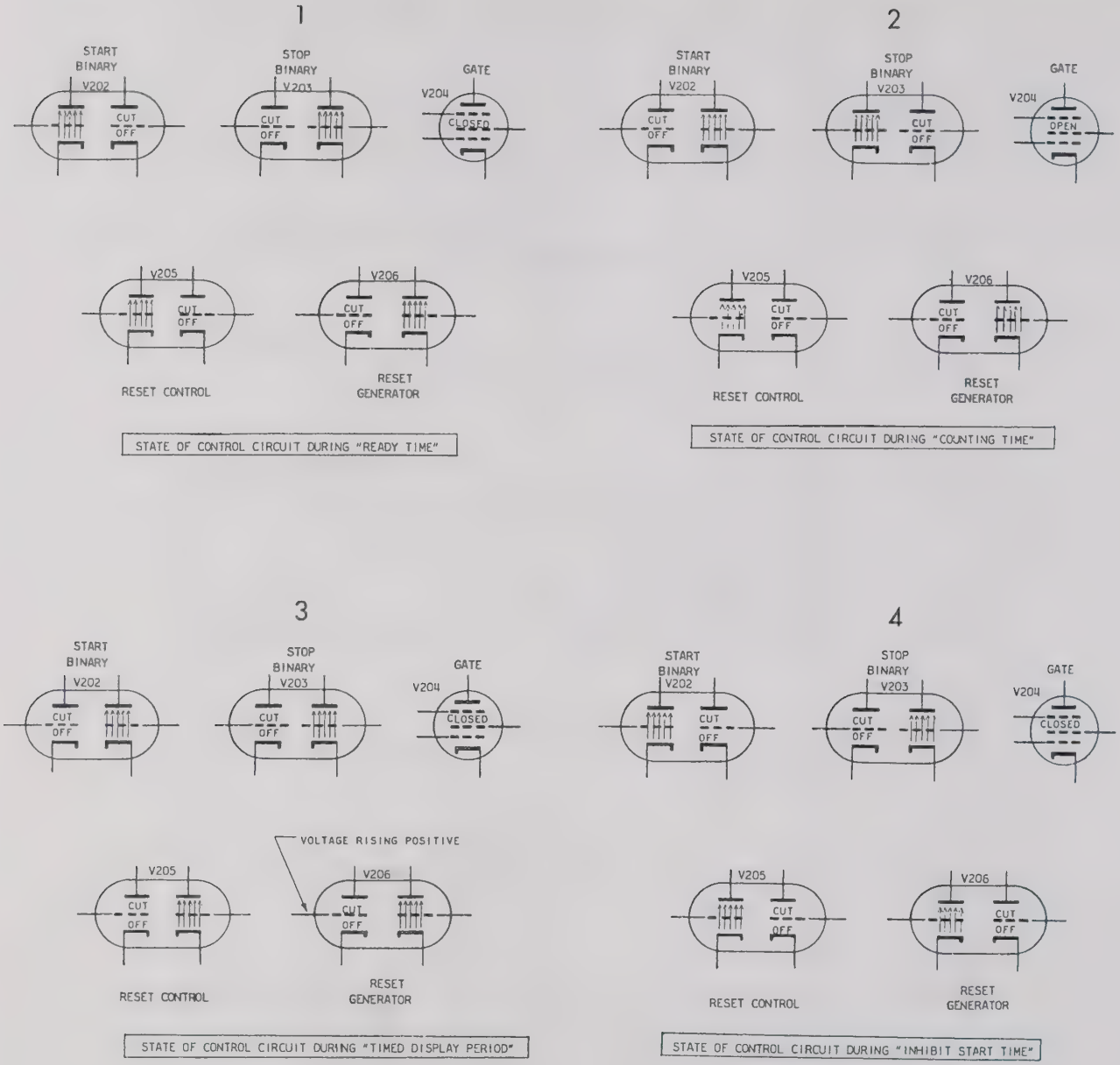


Figure 10 Tube States During the Operating Cycle

INPUT TRIGGER CHANNEL

The input trigger channel produces an output pulse each time the attenuated input signal passes a selected voltage level. The output is independent of input waveform. The channel consists of a Schmitt trigger voltage discriminator preceded by a two stage comparator amplifier. The input channel is preceded by an attenuator, which divides the input voltage by 1, 10 or 100 according to the position of the ATTENUATION control. The input impedance at all positions is about 10 megohms in parallel with 40 $\mu\mu$f. When the ATTENUATION control is at an AC position a .01 μf capacitor (C301) is inserted in series between the INPUT jack and the attenuator. The comparator amplifier has two stages. The first is a difference amplifier whose output is proportional to the input voltage on the grid of V301A minus a selected constant voltage on the grid of V301B. The TRIGGER VOLTAGE potentiometer (R318) varies the voltage on the grid of V301B between -1 and +1 volts. The second stage (V302) amplifies the double-ended signal received from V301 and converts it to a single-ended low impedance output at the left hand plate. This plate is connected to the input grid of the discriminator. The voltage discriminator (V303) produces an output pulse each time the input voltage on its left-hand grid passes through a fixed voltage level (about +60 volts). Consider the input to this circuit as an a-c triggering signal superimposed on a d-c level. The a-c signal is an amplified reproduction of the voltage variations on the grid of V301A, that is, the attenuated input. The d-c level is determined by the voltage on the grid of V301B, a voltage set by the TRIGGER VOLTAGE potentiometer. As the TRIGGER VOLTAGE control is rotated toward "+", the d-c level is lowered and the discriminator triggers at a higher instantaneous voltage of the a-c signal and at a higher attenuated input voltage to the channel. When the TRIGGER VOLTAGE control is turned toward "-", the channel triggers at a lower attenuated input voltage.

The discriminator (V303) is a two stage positive feedback amplifier. Feedback from the output stage occurs through the cathode coupling. The loop gain is slightly greater than one so that the circuit is regenerative and tends to assume one of two stable states. The output stage draws a steady current as long as the input grid remains below a certain triggering voltage. When the input exceeds this voltage the output tube is suddenly cut off. When the input voltage returns to a value slightly below the initial triggering voltage the output stage builds rapidly to its original steady current.

The difference between the level at which a positive-going voltage change triggers the circuit and the lower level at which a negative-going voltage change re-triggers it is called the hysteresis of the circuit. At the input to the comparator amplifier the hysteresis is about 0.3 volts. The hysteresis determines the input sensitivity. An attenuated input signal weaker than 0.3 volts peak-to-peak or about 0.1 volts rms will not trigger a series of pulses. This means that any noise at the attenuated input below this level will not trigger extraneous pulses, although it may affect the time at which a pulse occurs.

The primary winding of T301, differentiates the rapid current changes in the output stage to produce a positive pulse at the plate when the circuit is triggered by a positive-going voltage and a negative pulse when triggered by a negative-going voltage. The secondary of T301 produces inverted pulses -- a negative pulse when the circuit is triggered on a positive slope and a positive pulse when triggered on a negative slope.

DCU DIVIDER

Deck A of the FUNCTION switch (S201A) selects the signal which is divided by the DCU Divider (A201). During all operations other than "times ten" (x10) operations the output of DCU A202 is coupled to the input of this divider and it functions as the last in the chain, raising the maximum count indication to 9, 999, 999 on the Model 7360 or to 999, 999 on the Model 7350. During "times ten" operations the source of "start-stop" pulses is coupled to this divider through a two stage amplifier (V207), and the output of the divider becomes the "start-stop" input to the Control Circuitry. Since it produces an output pulse at every tenth input pulse, the time interval during which pulses are counted is ten times as large as it would be if the source of "start-stop" pulses drove the Control Circuitry directly. This DCU will not divide a frequency above 100 KC because its pulse resolution time is about 10 μseconds.

When the divider is part of the counting chain, Deck B of the FUNCTION switch (S201B) couples the reset pulse to pin 8 of the DCU Plug so that it resets to zero. During "times ten" operations Deck F of the FUNCTION switch connects pin 10 to -15 volts to extinguish the DCU indicator lamps and Deck D couples the reset pulse to pin 3 causing the divider to reset to nine. This is done so that the counting period will begin with the first input pulse rather than the tenth, thus eliminating an unnecessary delay.

CLOCK-PULSE GENERATOR

The Clock Pulse Generator provides:

1. Pulses of a known frequency which are counted between start and stop pulses to make time measurements.
2. Start and stop pulses separated by a known time interval over which events are counted to make events-per-unit-time measurements.

The circuitry consists of an oscillator, a pulse shaping circuit, a series of multivibrator frequency dividers, and an output trigger circuit. The shaper stage transforms the sinusoidal output of the oscillator into appropriate pulses. Each of the dividers divides the preceding frequency by ten. Decade frequencies from the shaper and the various dividers are selected by the TIME switch, shaped by the output trigger circuit (the Time Pulse Trigger) and applied to the FUNCTION switch, where they are available for start, stop or pulses to be counted.

OSCILLATOR

The oscillator circuit consists of two sections: a crystal controlled oscillator stage (V401A), followed by a buffer amplifier (V401B). The oscillator stage uses either a 1 megacycle or 100 kc, oven-controlled crystal (for Model 7360 or 7350 respectively). It is adjusted with the temperature stable capacitor, C410, which can shift the frequency of oscillation by a few cycles per second. Capacitor C404 has the nominal value given on the schematic diagram, but is selected at the factory to allow capacitor C410 to adjust the oscillator to the correct frequency.

The output of the oscillator stage drives the buffer amplifier, a pentode with a tuned circuit plate load. A portion of the output from the buffer amplifier is fed back to the oscillator stage to increase the amplitude stability of the signal.

SHAPER

The shaper stage (V402) amplifies and shapes the oscillator output for use as an input to the control circuitry and the dividers. The circuit is a voltage discriminator which operates in the same way as that discussed under "Input Trigger Channels". The trigger voltage level is set by adjusting R414. L402 differentiates the rapid current changes at the output plate to produce fast positive and negative pulses. The negative transients drive the first divider and the pulse output goes to the TIME SECONDS switch (where it may be selected to drive the Time Pulse Trigger). The output also goes directly to the FUNCTION switch where it provides pulses to be counted during TEST operation and the start pulse for COUNT operation.

DIVIDERS

The divider chain is a series of cascaded monostable multivibrators. Each produces one output pulse for every ten input pulses. The Model 7350 has five dividers which scale its 100 kc oscillator frequency down to 1 cps. The Model 7360 has an additional divider preceding the last five which scales its 1 mc oscillator frequency down to 100 kc. Although the 1 mc divider (V608) has additional circuitry to provide for high speed operation, it functions in essentially the same way as the others. The circuit operation will therefore be described with reference to V603.

With no input the circuit is stable; the right-hand side is conducting because its grid is connected to +120 VDC and the left-hand side is cut off. A negative transient reaching the input capacitor (C605) is coupled through R617 and R618 to each of the two plates. The negative pulse produced on the left plate is coupled by C609 to the right grid. It appears as an amplified positive pulse at the right plate, which is coupled to the left grid through C607. The left-hand side of the tube conducts, driving the left plate and the right grid even further negative. This regenerative action produces a quasi-stable state in which the right side is cut-off and the left side is conducting. In this state the voltage on the right grid (called the "timing grid") is rising relatively slowly as the voltage at the wiper of potentiometer R656 charges the timing capacitor (C609) through R645. At the same time negative input pulses at the right plate reach the left grid through C607 and appear as large positive pulses at the left plate. These pulses reach the timing grid through C609 and appear superimposed on the rising voltage curve there. (See Figure 11). When one of the positive pulses brings the timing grid above cutoff, the right side conducts and a reverse regenerative action returns the circuit to its original stable state. The slope of the rising grid voltage curve determines which of the successive positive pulses will rise above cutoff. The slope changes when the charging voltage at the wiper of R656 is raised or lowered. R656 is adjusted so that the ninth pulse rises above cutoff. The tenth pulse returns the circuit to the quasi-stable state.

In the interval between the ninth and tenth pulses the right side is conducting and the right plate is negative. The negative transient produced is the useful output of the divider. It drives the next divider stage and also goes to the TIME SECONDS switch where it is available as a clock signal.

The additional circuitry associated with the 1 MC divider (V608) speeds up its response. V608 is a multivibrator which operates just as V603. V607B is a cathode follower inserted between left plate of the multivibrator and the timing grid. Its function is to discharge C628, the timing capacitor, within the brief 1 microsecond output pulse period so that the capacitor will pass the next positive pulse to the grid. V607A functions

as a diode clamp on the left grid of the multivibrator. It prevents this grid from going so far negative during the 1 microsecond pulse output period that it will not rise above cutoff when the next positive pulse reaches it.

TIME PULSE TRIGGER

The TIME switch selects a negative output transient from one of the divider stages and feeds it to the Time Pulse Trigger (V601). The Time Pulse Trigger is a voltage discriminator which operates in the same way as that described under "Input Trigger Channels". Output clock pulses produced at L601 are coupled to the FUNCTION switch.

POWER SUPPLY

Two bridge rectifiers supply +210 volts unregulated and -110 volts unregulated. From these voltages are derived +120 volts regulated, -60 volts regulated, and -35 volts unregulated.

A Zener diode (CR106) stabilizes the -60 volt supply. This in turn acts as a reference voltage for the +120 volt regulator circuit, which consists of an amplifier (V101) and a series regulator tube (V102). A voltage divider (R106, R107, R113, R116) is connected between the regulated +120 volt supply and the -60 volt reference. The control grid of V101 is connected to a point on this divider that is adjusted by R113 (the +120 V ADJUST control) to be slightly below ground when the regulated output is +120 volts. Since the plate of V101 is coupled through R105 and

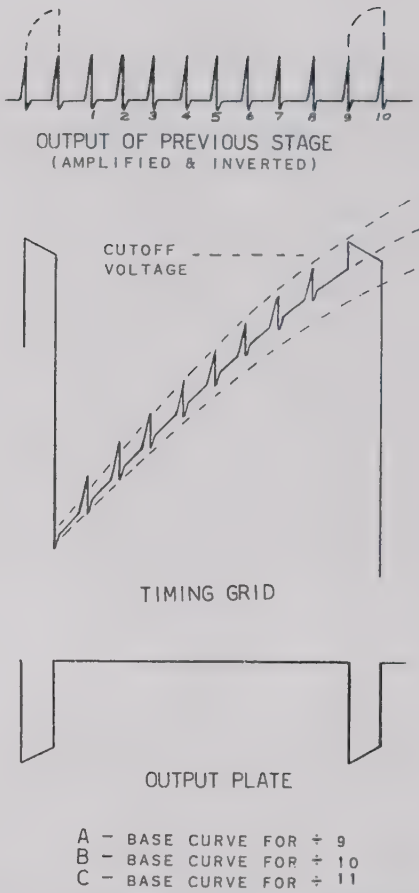
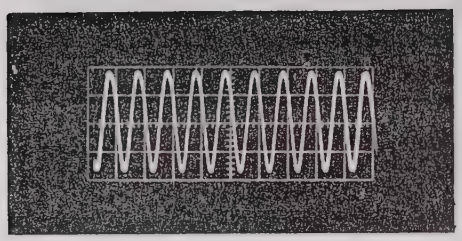
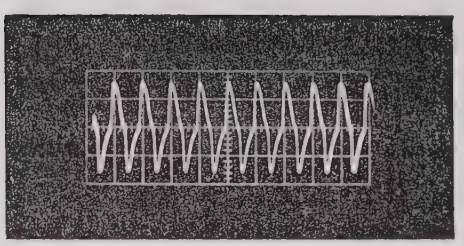


Figure 11 Divider Stage Waveforms

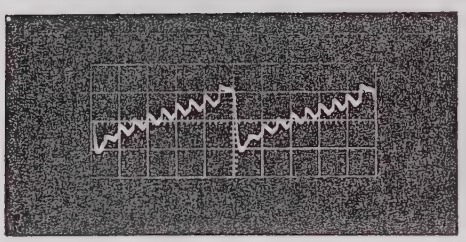
R110 to the control grids of V102, any increase in the regulated output voltage appears as a decrease in the grid bias applied to V102. The plate resistance of V102 increases, and with it the voltage drop across the tube; so the output voltage drops back to +120 volts. Similarly, if the output voltage goes down, the plate resistance of V102 decreases, thus restoring the output to +120 volts.



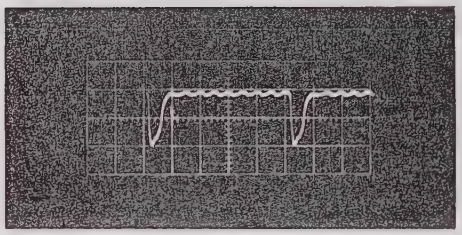
1 MC Oscillator output (V401, pin 6).
Vert. scale: 5v./div.
Horiz. scale: 1μs/div.



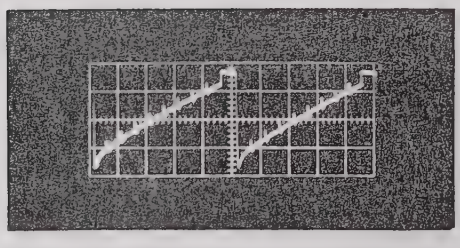
Shaper output (V402, pin 1).
Vert. scale: 5v./div.
Horiz. scale: 1μs/div.



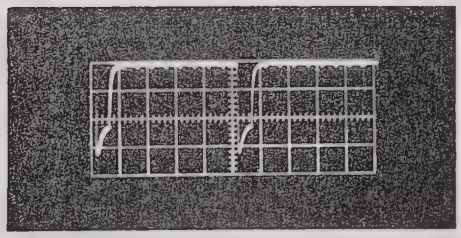
1 MC Divider, timing grid (V608, pin 2).
Vert. scale: 10v./div.
Horiz. scale: 2μs/div.



1 MC Divider output (junction of R666 and R668).
Vert. scale: 10v./div.
Horiz. scale: 2μs/div.

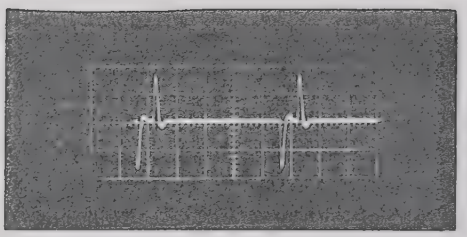


100 KC Divider, timing grid (V602, pin 7).
Vert. scale: 10v./div.
Horiz. scale: 20μs/div.

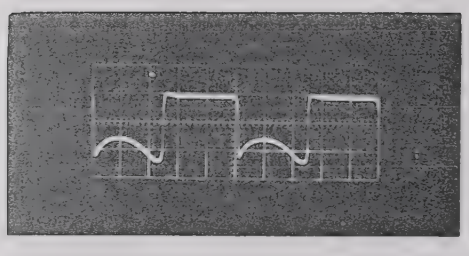


100 KC Divider output (V602, pin 6).
Vert. scale: 20v./div.
Horiz. scale: 20μs/div.

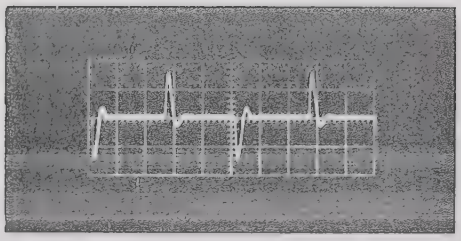
Figure 12a Typical Waveforms



Time Pulse Trigger, 100 KC output (V601, pin 1).
Vert. scale: 5v./div.
Horiz. scale: 2μs/div.

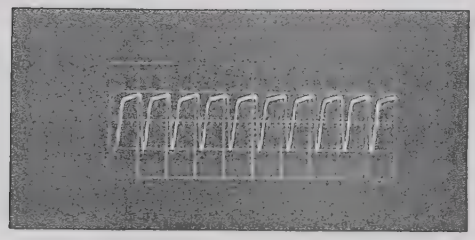


Discriminator Amplifier plate (V303, pin 6); with 100 KC input signal.
Vert. scale: 5v./div.
Horiz. scale: 2μs/div.



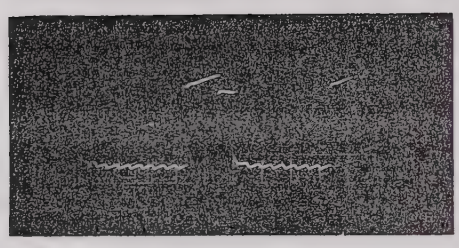
Discriminator output (V303, pin 1); with 100 KC input signal.
Vert. scale: 5v./div.
Horiz. scale: 2μs/div.

Start Binary output (V202, pin 6) with FUNCTION switch at TEST, TIME switch at "10^{-2}". (Upper level of waveform is at -11 volts).
Vert. scale: 20v./div.
Horiz. scale: 20ms/div.



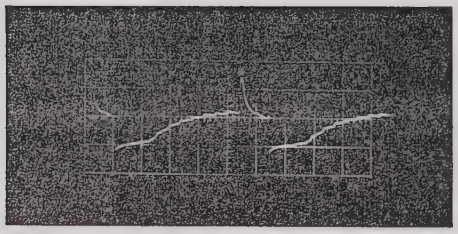
Signal Gate output (V204, pin 5); with 1 MC input signal.
Vert. scale: 5v./div.
Horiz. scale: 1μs/div.

Figure 12b Typical Waveforms



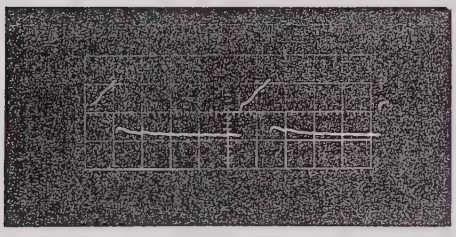
Reset Control input (junction of R236 and R239) or print command (J202, pin 39); with FUNCTION switch at TEST, TIME switch at "10^{-2}", and minimum display time.

Vert. scale: 10v./div.
Horiz. scale: 20ms/div.



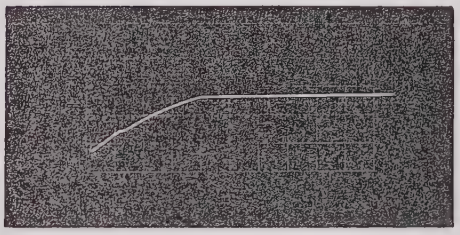
Reset Generator input (V206, pin 7); with FUNCTION switch at TEST, TIME switch at "10^{-2}", and minimum display time.

Vert. scale: 20v./div.
Horiz. scale: 20ms/div.



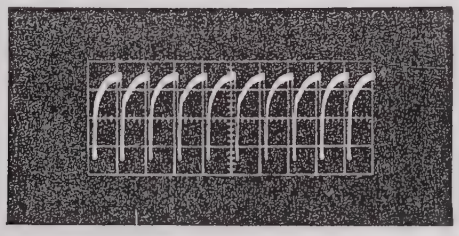
Reset Generator output (V206, pin 1); with FUNCTION switch at TEST, TIME switch at "10^{-2}", and minimum display time.

Vert. scale: 50v./div.
Horiz. scale: 20ms/div.



Reset pulse (junction of C215 and CR205); 5 μs rise time.

Vert. scale: 50v./div.
Horiz. scale: 500μs/div.



DCU Divider Drive output (V207, pin 6); with FUNCTION switch at E/UT X 10, TIME switch at "10^{-5}".

Vert. scale: 50v./div.
Horiz. scale: 10μs/div.

Figure 12c Typical Waveforms

4 Maintenance

ROUTINE ADJUSTMENTS

OSCILLATOR

The frequency of oscillation can be adjusted by a small amount with the XTAL ADJ control at the top of the chassis. To make this adjustment, rotate the control until the oscillator output signal (which appears at the FREQ jack) produces a zero beat with a signal from WWV or some other highly accurate frequency standard. The Beckman/Berkeley Model 905 Receiver, which operates at any of the six standard WWV frequencies, is especially useful for this purpose.

NOTE

Whenever the oscillator crystal is replaced, it may be necessary to change capacitor C404 so that the frequency of oscillation can be adjusted to the correct value.

SHAPER

The shaper stage in the clock-pulse generator is a voltage discriminator similar to those in the Input Trigger Channels. The SHAPER LEVEL control, located on the top side of the counter chassis, sets the trigger voltage at the input to this circuit. To adjust, set the FUNCTION switch at TEST. Find the limits of the range of adjustment in which the instrument continues to count. Set the control at the center of this range.

NOTE

On the Model 7360, this adjustment should be checked at both the 10^{-6} and 10^{-5} settings of the TIME-SECONDS selector.

DIVIDERS

If the instrument fails to indicate correctly with the FUNCTION switch at TEST, one or more dividers may be out of adjustment. Some Model 7360 instruments may read "9" with the TIME switch at 10^{-5} and "99" with the switch at 10^{-4}. These readings are correct provided the unit reads "999,999" or "1,000,000" at the 1 second position. Dividers should be adjusted using the potentiometer controls located under the cabinet lid and labeled "ADJ 1 SEC; ADJ 10^{-1} SEC;" etc. To adjust, place the FUNCTION switch at TEST, then follow the procedure for the model you are servicing.

Adjustment procedure for Model 7350.

1. Turn TIME switch to 10^{-4} and measure the d-c voltage between test point E4 and ground. Rotate the ADJ 10^{-4} SEC control to the extremes of the range in which reading of 10 appears on the DCU's, noting the test point voltage at each extreme. Then adjust the control until the test point voltage is midway between the extreme values.
2. Turn TIME switch to 10^{-3}. Measure voltage at E3. Rotate ADJ 10^{-3} SEC control to extremes of range which reads "100", noting test points voltages at extremes. Adjust control until voltage is halfway between extremes.
3. With TIME switch at 10^{-2}, set ADJ 10^{-2} SEC control similarly but to center of voltage range in which either 1000 or 999 appears.
4. Adjust the remaining controls in order to the center of the 10,000 or 9,999 range, and the 100,000 or 99,999 range.

Adjustment procedure for Model 7360.

1. Turn TIME switch to 10^{-5} and measure the d-c voltage between test point E5 and ground. Rotate the ADJ 10^{-5} SEC control to the extremes of the range in which a reading of 10 appears on the DCU's noting the test point voltage at each extreme. Then adjust the control until the test point voltage is midway between the extreme values.

2. With TIME switch at 10^{-4}, rotate the ADJ 10^{-4} SEC control to the center of the range in which either 99 or 100 appears.

3. With TIME switch at 10^{-3}, rotate the ADJ 10^{-3} SEC control to the center of the range in which 999 or 1000 appears.

4. If neither of these readings can be obtained, return the TIME switch to 10^{-5} and re-adjust the ADJ 10^{-5} SEC control to the center of the range in which 9 (rather than 10) appears. Then, repeat steps 2 and 3 above.

5. With TIME switch at 10^{-3}, adjust all three controls (10^{-5}, 10^{-4} & 10^{-3}) to the center of the range in which either 999 or 1000 appears.

6. Adjust the remaining controls in order to the center of the 10,000 or 9,999 range, the 100,000 or 99,999 range and the 1,000,000 or 999,999 range.

The adjustment of each divider affects the adjustment of the others slightly. Therefore, after the initial adjustment outlined above, a final adjustment should be made. With the FUNCTION switch at TEST, set the TIME switch to 10^{-1}.

On the Model 7360, a reading of 100,000 or 99,999 will appear. Adjust in turn ADJ 10^{-5} SEC thru ADJ 10^{-1} SEC to the center of the corresponding test point voltage range within which either of these readings appears. Then, set the TIME switch at 1 and rotate ADJ 1 SEC to the center of the voltage range at E0 within which either 1,000,000 or 999,999 appears.

On the Model 7350, a reading of 10,000 or 9,999 will appear. Adjust in turn ADJ 10^{-4} SEC thru ADJ 10^{-1} SEC to the center of the corresponding test point voltage range within which either of these readings appears. Then move the TIME switch to 1 and rotate ADJ 1 SEC to the center of the voltage range at E0 within which either 100,000 or 99,999 appears.

REGULATED 120 VOLT SUPPLY

With an accurate voltmeter, measure the supply voltage at the test point labeled "+120" (located at the top of the chassis). If necessary, adjust the +120V ADJUST control, located on the rear panel of the instrument, for a reading of 120 volts.

TIME PULSE TRIGGER

The Time Pulse Trigger (V601) is a Schmitt trigger circuit. The TIME TRIGGER LEVEL control varies the instantaneous voltage at which an input signal triggers the circuit from one state to another. Whenever the tube is replaced, adjust the control until, with no input signal, the potential on the input grid (Pin 2) is -1 volts with respect to the cathode (pin 7). Check TEST operation under two conditions: (1) line power reduced to 105 volts and TIME switch at 1 second (2) normal line voltage and TIME switch at 10^{-6} seconds. An incorrect adjustment will cause either a reading of 100,000 rather than 1,000,000 at the 1 second position or no reading instead of "1" on the 10^{-6} seconds position. If necessary, re-adjust the control until correct readings are obtained under both conditions.

ATTENUATOR ADJUSTMENTS

The ceramic trimmer capacitors on the attenuator assembly must be adjusted properly to prevent the attenuator from distorting the input signal. When the counter chassis is upside down and the attenuator shaft is pointing at the viewer, the capacitor on the right side of the attenuator is C303 and that on the left C302. To adjust, apply a 500 cps square wave signal to the front panel INPUT jack. Observe the corresponding amplifier output at Pin 1 of V302 with a 100KC band-width oscilloscope. Turn the attenuator to 10 on the AC side. Adjust the input signal to about 1 volt peak-to-peak. Adjust the TRIGGER VOLTAGE control to any position in which the channel triggers. Adjust C303 for a square wave output. Then, turn the attenuation control to 100 on the AC side and adjust the input signal to about 10 volts peak-to-peak. Adjust C302 for a square wave output.

TROUBLESHOOTING

The following test equipment is necessary to service the instrument effectively:

1. An oscilloscope, sensitivity 1/4 volt, bandwidth 5 MC, preferably direct coupled.

2. A signal generator, frequency range 100 cps to 1 MC, output at least 100 mv rms.

3. A vacuum tube voltmeter.

When the instrument fails to perform properly, first make sure that it is being operated correctly. Some common errors in operation are:

1. TRIGGER VOLTAGE control positioned incorrectly.

2. ATTENUATION control set incorrectly.

   (a) Wrong choice of AC or DC coupling.

   (b) Attenuated signal too strong or too weak.

3. SLOPE switches set incorrectly. (See "PERFORMING SPECIFIC OPERATIONS" for correct setting for each operation.)

4. Input signal coupled to wrong jack.

5. FUNCTION switch set at "times ten" position when original start-stop frequency is above 100 KC. For example:

   (a) FUNCTION switch at E/UT x 10 and TIME switch at 10^{-6}.

   (b) FUNCTION switch at A/B x 10 when B frequency is above 100 KC.

6. Wrong TIME switch setting.

   (a) Unit of time measurement too large to measure a brief period under PERIOD operation.

   (b) Time interval too short to measure a low frequency under events-per-unit-time operation.

7. Too much noise on input signal.

When it is certain the instrument is functioning improperly, first check the power supply voltages to see that they lie within the limits listed below.

Supply	Limits of Average Level	Acceptable Ripple, peak to peak
Unreg. Pos.	+200 to +230 v	15 v
Unreg. Neg.	-100 to -120 v	12 v
Reg. Pos.	+120 v	0.1 v
Reg. Neg.	-54 to -66 v	0.4 v

If the supply voltages are adequate, the next step is to trace the failure to one of the major components. This can be done by observing the start, stop and count pulses at Decks C, E & G respectively of the FUNCTION switch. If the signals at these points approximate the proper output waveforms of the pulse sources, the trouble lies in the Gate and Control Circuitry or the indicating DCU's. Refer to the master schematic diagram to determine the source of pulses when the FUNCTION switch is in a particular position. If a deficient pulse is found, the trouble lies in that pulse source.

When the trouble has been traced to one of the major components, consult the Circuit Description section of this manual and the waveforms of Figure 12 for guidance in locating the specific fault. The Input Trigger Channels may be conveniently checked by observing whether or not a pulse is produced as the TRIGGER VOLTAGE control is rotated from one extreme to the other and back.

Tubes, chokes, germanium diodes and pulse transformers are the most common sources of trouble. A transconductance tube tester will not always detect a faulty tube and, conversely, the tester may reject a tube which is functioning

properly. Although the circuits are designed for wide tube variation, avoid swapping tubes or wholesale replacement. An aged tube is generally more reliable than a new tube, because catastropic failure usually occurs early in the life of a tube if at all. An aged tube undergoes only a gradual loss of transconductance, emission, etc.

The Sylvania 6U8 tube is recommended for use in trigger circuits V402, V601 and V303. (There are two V303 stages -- one in each input trigger channel.)

PREVENTIVE MAINTENANCE

Since a tube tester will not detect tubes which are likely to cause trouble and it is undesirable to replace tubes wholesale as they grow old, other methods must be used to forestall failures. The most effective method is "marginal checking". In its simplest form this consists in causing intermittent or latent failures to manifest themselves by operating the instrument at exceptionally high or low line voltages. A variable auto-transformer may be used to manipulate the line voltage.

5 Parts List

The sub-assemblies contained in this parts list are identified as follows:

Beckman Stock No.	Description	Page
855-402144	Indicator (Models 7350A & 7360A)	5-1
855-401723	Reset (Models 7350A & 7360A)	5-2
855-402215	Function Switch (Models 7350A & 7360A)	5-2
855-401683	Attenuator Switch (Models 7350A & 7360A)	5-3
855-401700	Power Supply (Models 7350A & 7360A)	5-3
855-402068	Time Base (Model 7350A)	5-4
855-401693	Signal Gate (Model 7350A)	5-6
855-402093	100 Kc Pot Bracket (Model 7350A)	5-7
855-402047	Oscillator (Model 7350A)	5-7
855-402139	Time Base (Model 7360A)	5-8
855-413454	Signal Gate (Model 7360A)	5-9
855-402188	Input Channel (Model 7360A)	5-9
855-402054	1 Mc Oscillator (Model 7360A)	5-10
	Miscellaneous:	
	Decimal Counting Units	5-11
	Components	5-11

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
	855-402144	INDICATOR (Models 7350A & 7360A)	Beckman	1
C216	651-099061	Capacitor, F. Mylar, 1μf, 200V, 20%	G. E. Type 64F	1
C217	639-804876	Capacitor, F. Paper, 0.5μf, 200V	Hopkins P52DS	1
C218	633-804718	Capacitor, F. Ceramic, 0.01μf, 600V	Erie 811-.01	1
C220	637-819113	Capacitor, F. Mica, 100pf, 500V	Sangamo RR5E101J03	2
C221	637-804748	Capacitor, F. Mica, 51pf, 500V	Sangamo RR1451	1
C222		Same as C220		
C223 thru C246	633-804706	Capacitor, F. Ceramic, 0.001μf, 600V	Centralab DD-102	24
CR205	755-402107	Diode, Special, Selected, 1N95	Beckman	4
CR206	755-404593	Diode, Silicon, Special	Beckman	1
CR207 thru CR209		Same as CR205		
J202	672-806833	Connector, Receptacle, 40-Pin	Cannon DPX-40-34S	1
R231	601-008147	Resistor, F. Comp., 910k, 1/2W, 5%	Allen Bradley EB9145	2
R232	601-041151	Resistor, F. Comp., 1M, 1/2W, 5%	Allen Bradley EB1055	4
R233		Same as R232		
R234		Same as R231		
R238	601-015070	Resistor, F. Comp., 68k, 1/2W, 5%	Allen Bradley EB6835	1
R242 & R243		Same as R232		
R244	601-000565	Resistor, F. Comp., 22k, 1/2W, 5%	Allen Bradley EB2235	2
R252	601-015460	Resistor, F. Comp., 3.3k, 1/2W, 5%	Allen Bradley EB3325	1
R253	601-015053	Resistor, F. Comp., 10k, 2W, 5%	Allen Bradley HB1035	1
R254	601-800147	Resistor, F. Comp., 22k, 2W, 5%	Allen Bradley HB2235	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R255	601-015086	Resistor, F. Comp., 470k, 1/2W, 5%	Allen Bradley EB4745	1
R256	601-000899	Resistor, F. Comp., 4.7k, 1/2W, 5%	Allen Bradley EB4725	1
R257	601-015038	Resistor, F. Comp., 1k, 1/2W, 5%	Allen Bradley EB1025	1
R258		Same as R244		
R260	601-000897	Resistor, F. Comp., 2.2k, 1/2W, 5%	Allen Bradley EB2225	1
R261	601-015052	Resistor, F. Comp., 10k, 1/2W, 5%	Allen Bradley EB1035	1
R262	601-015068	Resistor, F. Comp., 56k, 1/2W, 5%	Allen Bradley EB6535	1
R267	601-043189	Resistor, F. Comp., 39k, 1W, 5%	Allen Bradley GB3935	1
XA201	860-016990	Socket, 11-Pin	Amphenol 77-MIP-11	7
XA202 thru XA207		Same as XA201		
XV205 thru XV207	860-802336	Socket, Tube, 9-Pin	Elco 3778C	3
	855-401723	RESET (Models 7350A & 7360A)	Beckman	1
C214	639-007467	Capacitor, F. Paper, 0.1μf, 400V, 20%	Hopkins 1P2D	1
C215	633-804722	Capacitor, F. Ceramic, 0.02μf, 600V	Erie 817-.02	1
C247 & C248	633-804718	Capacitor, F. Ceramic, 0.01μf, 700V	Erie 811-.01	2
CR206	755-404593	Diode, Silicon, Special	Beckman	1
R204	601-041151	Resistor, F. Comp., 1M, 1/2W, 5%	Allen Bradley EB1055	1
R205	601-015038	Resistor, F. Comp., 1k, 1/2W, 5%	Allen Bradley EB1025	2
R212	601-015052	Resistor, F. Comp., 10k, 1/2W, 5%	Allen Bradley EB1035	2
R213		Same as R212		
R235	601-015064	Resistor, F. Comp., 47k, 1/2W, 5%	Allen Bradley EB4735	3
R236	601-015086	Resistor, F. Comp., 470k, 1/2W, 5%	Allen Bradley EB4745	1
R237	601-015074	Resistor, F. Comp., 100k, 1/2W, 5%	Allen Bradley EB1045	1
R239		Same as R235		
R240	601-008129	Resistor, F. Comp., 1.5k, 1/2W, 5%	Allen Bradley EB1525	1
R241		Same as R205		
R249		Same as R235		
R250	601-800146	Resistor, F. Comp., 15k, 2W, 5%	Allen Bradley HB1535	1
R251	601-800013	Resistor, F. Comp., 3.3M, 1/2W, 5%	Allen Bradley EB3355	1
	855-402215	FUNCTION SWITCH (Models 7350A & 7360A)	Beckman	1
C201	637-804777	Capacitor, F. Mica, 500pf, 500V	Sangamo RR1350	4
C206		Same as C201		
C212		Same as C201		
C219		Same as C201		
L201	795-807920	Choke, 500 mH	Wilco 1500-15	1
R259	601-000897	Resistor, F. Comp., 2.2k, 1/2W, 5%	Allen Bradley EB2225	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R264	601-015074	Resistor, F. Comp., 100k, 1/2W, 5%	Allen Bradley EB1045	3
R265		Same as R264		
R278		Same as R264		
S201	711-402110	Switch, Rotary, 4 Sec., 11 Pos.	Beckman	1
	855-401683	ATTENUATOR SWITCH (Models 7350A & 7360A)	Beckman	1
C301	633-804718	Capacitor, F. Ceramic, 0.01μf, 600V	Erie 811-.01	1
C302 & C303	643-804005	Capacitor, Variable 5-25μf, 500V	Erie 557-F	2
C304	637-804739	Capacitor, F. Mica, 20pf, 500V, 5%	Sangamo RR1420	1
C305	637-804800	Capacitor, F. Mica, 3300pf, 500V, 5%	Sangamo CR1233	1
C306	637-804768	Capacitor, F. Mica 300pf, 500V, 5%	Sangamo RR1330	1
R301	601-008154	Resistor, F. Comp., 10M, 1/2W, 5%	Allen Bradley EB1065	2
R302	601-008856	Resistor, F. Comp., 9.1M, 1/2W, 5%	Allen Bradley EB9155	1
R303	601-015074	Resistor, F. Comp., 100k, 1/2W, 5%	Allen Bradley EB1045	1
R304	601-041151	Resistor, F. Comp., 1M, 1/2W, 5%	Allen Bradley EB1055	1
R305		Same as R301		
S301	711-402101	Switch, Rotary, 2 Sections	Beckman	1
	855-401700	POWER SUPPLY (Models 7350A & 7360A)	Beckman	1
B101	842-412209	Fan Motor, 115V, 60 cps, 3400 RPM	Beckman	1
C101	631-802975	Capacitor, F. Elect., 125μf, 350V	Mallory FP140	2
C102 & C103	633-804718	Capacitor, F. Ceramic, 0.01μf, 600V	Erie 811-.01	4
C104	631-802946	Capacitor, F. Elect., 8μf, 250V	Cornell-Dub. BR825	1
C105		Same as C102		
C106		Same as C101		
C107		Same as C102		
C108	638-091715	Capacitor, F. Paper, 0.1μf, 200V, 20%	Sangamo 330201	1
CR101	755-416842	Diode, Silicon, 600PIV, 1A, Special	Beckman	4
CR102 thru CR104		Same as CR101		
CR105	774-808191	Rectifier, Selenium, 110V RMS	G.E. 6RS21PB3AT1	1
CR106	755-402092	Rectifier, Silicon	Beckman	1
J203	683-806914	Jack, Nylon, Black	Whitso JNP-11	1
J401	670-806738	Connector, Receptacle, UG1094/U	Amphenol UG-1094/U	2
J601		Same as J401		
R101	604-800932	Resistor, F. W.W., 10W, 10%	Tru-Ohm FRL-10-20-10%	1
R102 & R103	601-015064	Resistor, F. Comp., 47k, 1/2W, 5%	Allen Bradley EB4735	3
R104	601-015074	Resistor, F. Comp., 100k, 1/2W, 5%	Allen Bradley EB1045	1
R105	601-015038	Resistor, F. Comp., 1k, 1/2W, 5%	Allen Bradley EB1025	2

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R106	607-801153	Resistor, F. Film, 1M, 1W, 5%	Arnhold A-2-1M-5%	1
R107	614-806335	Resistor, V. Comp., 500k, 2W, 20%	Allen Bradley JA1N0-48S504MZ	1
R108 & R109	601-012272	Resistor, F. Comp., 47Ω, 2W, 10%	Allen Bradley HB4701	2
R110		Same as R105		
R111 & R112	601-800181	Resistor, F. Comp., 22Ω, 2W, 10%	Allen Bradley GB2201	2
R113	607-801148	Resistor, F. Film, 500k, 1W, 5%	Arnhold A-2-500k-5%	1
R116		Same as R102		
R117	601-002211	Resistor, F. Comp., 100k, 1/2W, 10%	Allen Bradley EB1041	1
R118	601-801559	Resistor, F. Comp., 47k, 1/2W, 10%	Allen Bradley EB4731	1
XF101 & XF102	735-007268	Fuseholder, for 3AG Fuses	Bussman HKP	2
XV101	860-802323	Socket, Tube, 7-Pin	Elco 316BC	1
XV102	860-802331	Socket, Tube, Octal	Cinch Mfg. 9950	1

	855-402068	TIME BASE (Model 7350A)	Beckman	1
C601	633-804707	Capacitor, F. Cerm., 1000pf, 600V	Erie GP2L-102	2
C602	637-804738	Capacitor, F. Mica, 15pf, 500V, 5%	Sangamo RR1415	1
C603		Same as C601		
C604	637-807482	Capacitor, F. Mica, 10pf, 500V, 5%	Sangamo RR1410	5
C605	637-804741	Capacitor, F. Mica, 24pf, 500V, 5%	Sangamo RR1424	4
C606	635-804930	Capacitor, F. Glass, 56pf, 500V, 5%	Vitramon CY13C560J-A	1
C607		Same as C604		
C608		Same as C605		
C609	635-804733	Capacitor, F. Glass, 470pf, 500V, 5%	Vitramon CY17C471J-A	1
C610		Same as C604		
C611		Same as C605		
C612	639-804885	Capacitor, F., Paper, 0.0047μf, 300Vdc, 5%	Sangamo SKB3K03472J	1
C613		Same as C604		
C614		Same as C605		
C615	639-804888	Capacitor, F., Paper, 0.047μf, 300Vdc, 5%	Sangamo SDB3K03473J	1
C616		Same as C604		
C617	639-804892	Capacitor, F., Paper, 0.47μf, 300Vdc, 5%	Sprague 186P47453S3	1
C618	633-804718	Capacitor, F., Ceramic, 0.01μf, 600V	Erie 811-.01	5
C619 thru C622		Same as C618		
CR601	755-409096	Diode, Type 1N198, Selected	Beckman	2
CR602		Same as CR601		
L601	795-807915	Inductor, F., R.F., 0.300mH	Wilco 1300-15	1
R601	601-015072	Resistor, F., Comp., 82k, 1/2W, 5%	Allen Bradley EB8235	1
R602	601-015047	Resistor, F., Comp., 3.9k, 1/2W, 5%	Allen Bradley EB3925	1
R603	601-000897	Resistor, F., Comp., 2.2k, 1/2W, 5%	Allen Bradley EB2225	2

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R604	601-015038	Resistor, F., Comp., 1k, 1/2W, 5%	Allen Bradley EB1025	1
R605	601-015070	Resistor, F., Comp., 68k, 1/2W, 5%	Allen Bradley EB6835	1
R607	601-015197	Resistor, F., Comp., 6.8k, 1W, 5%	Allen Bradley GB6825	1
R608	601-015052	Resistor, F., Comp., 10k, 1/2W, 5%	Allen Bradley EB1035	6
R609	601-022948	Resistor, F., Comp., 15k, 1/2W, 5%	Allen Bradley EB1535	1
R610	601-015443	Resistor, F., Comp., 330Ω, 1/2W, 5%	Allen Bradley EB3315	1
R611		Same as R603		
R612	601-000565	Resistor, F., Comp., 22k, 1/2W, 5%	Allen Bradley EB2235	5
R613	601-015086	Resistor, F., Comp., 470k, 1/2W, 5%	Allen Bradley EB4745	5
R614		Same as R608		
R615	601-029323	Resistor, F., Comp., 12k, 1/2W, 5%	Allen Bradley EB1235	6
R616		Same as R612		
R617	601-015079	Resistor, F., Comp., 150k, 1/2W, 5%	Allen Bradley EB1545	9
R618	601-015083	Resistor, F., Comp., 220k, 1/2W, 5%	Allen Bradley EB2245	4
R619		Same as R613		
R620		Same as R608		
R621		Same as R615		
R622		Same as R612		
R623		Same as R617		
R624		Same as R618		
R625		Same as R613		
R626		Same as R608		
R627		Same as R615		
R628		Same as R612		
R629		Same as R617		
R630		Same as R618		
R631		Same as R613		
R632		Same as R608		
R633		Same as R615		
R634		Same as R612		
R635		Same as R617		
R636		Same as R618		
R637		Same as R613		
R638		Same as R608		
R639		Same as R615		
R640		Same as R617		
R641	601-015044	Resistor, F., Comp., 8.2k, 1/2W, 5%	Allen Bradley EB8225	5
R642	607-815763	Resistor, F., Film, 3.3M, 1W, 10%	Electra DC1-395F	1
R643		Same as R617		
R644		Same as R641		
R645	607-812008	Resistor, F., Film, 3.9M, 1W, 1%	Electra DC-1-3.9M-1%	4
R646		Same as R617		
R647		Same as R641		
R648		Same as R645		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R649		Same as R617		
R650		Same as R641		
R651		Same as R645		
R652		Same as R617		
R653		Same as R641		
R654		Same as R645		
R661	601-015050	Resistor, F., Comp., 5.6k, 1/2W, 5%	Allen Bradley EB5625	1
R662		Same as R615		
S601	711-402106	Switch, Rotary, 2 Sec., 8 Pos.	Beckman	1
XV601	860-802336	Socket, Tube, 9-Pin, w/o Shield, w/Lugs	Elco 377BC	6
XV602 thru XV606		Same as XV601		
	855-401693	SIGNAL GATE (Model 7350A)	Beckman	1
C202	637-804744	Capacitor, F., Mica, 33pf, 500V	Sangamo RR1433	2
C203	639-804917	Capacitor, F., Paper, 0.25μf, 500V	Sangamo 3304025	1
C204	633-804717	Capacitor, F., Ceramic, 0.01μf, 500V	Sprague 29C9B5	3
C205		Same as C202		
C207	637-804741	Capacitor, F., Mica, 24pf, 500V	Sangamo RR1424	2
C208	637-804740	Capacitor, F., Mica, 22pf, 500V	Sangamo RR1422	2
C209		Same as C204		
C210		Same as C208		
C211		Same as C207		
C213		Same as C204		
CR201	755-404593	Diode, Special, Silicon	Beckman	3
CR203		Same as CR201		
CR204	755-402107	Diode, Selected, Type 1N95	Beckman	1
CR211	755-409096	Diode, Selected, Type 1N198	Beckman	2
CR212		Same as CR211		
CR213		Same as CR201		
R202	601-029323	Resistor, F., Comp., 12k, 1/2W, 5%	Allen Bradley EB1235	4
R203		Same as R202		
R206	601-015086	Resistor, F., Comp., 470k, 1/2W, 5%	Allen Bradley EB4745	1
R207	601-015074	Resistor, F., Comp., 100k, 1/2W, 5%	Allen Bradley EB1045	2
R208		Same as R207		
R209		Same as R202		
R210	601-015068	Resistor, F., Comp., 56k, 1/2W, 5%	Allen Bradley EB5635	4
R211		Same as R210		
R214	601-015052	Resistor, F., Comp., 10k, 1/2W, 5%	Allen Bradley EB1035	1
R215	601-017528	Resistor, F., Comp., 330k, 1/2W, 5%	Allen Bradley EB3345	1
R216	601-001393	Resistor, F., Comp., 7.5k, 1W, 5%	Allen Bradley GB4725	2
R217		Same as R216		
R218	601-015079	Resistor, F., Comp., 150k, 1/2W, 5%	Allen Bradley EB1545	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R219	601-015081	Resistor, F., Comp., 180k, 1/2W, 5%	Allen Bradley EB1845	2
R220	601-001554	Resistor, F., Comp., 680k, 1/2W, 5%	Allen Bradley EB6845	1
R221		Same as R202		
R222		Same as R210		
R223	601-015057	Resistor, F., Comp., 20k, 1/2W, 5%	Allen Bradley EB2035	2
R224		Same as R210		
R225		Same as R223		
R226	601-015047	Resistor, F., Comp., 3.9k, 1/2W, 5%	Allen Bradley EB3925	2
R227	601-000565	Resistor, F., Comp., 22k, 1/2W, 5%	Allen Bradley EB2235	2
R228	601-015083	Resistor, F., Comp., 220k, 1/2W, 5%	Allen Bradley EB2245	3
R229		Same as R227		
R230	601-015038	Resistor, F., Comp., 1k, 1/2W, 5%	Allen Bradley EB1025	1
R246		Same as R219		
R263		Same as R228		
R266	601-079172	Resistor, F., Comp., 820Ω, 1/2W, 5%	Allen Bradley EB8215	1
R280		Same as R228		
XV202	860-802336	Socket, Tube, 9-Pin	Elco 377BC	2
XV203		Same as XV202		
XV204	860-802323	Socket, Tube, 7-Pin	Elco 316BC	1
	855-402093	100 KC POT BRACKET (Model 7350A)	Beckman	1
C623	633-804718	Capacitor, F., Ceramic, 0.01μf, 600V	Erie 811-.01	1
R606	614-806323	Resistor, Var., Comp., 50k, 2W, 10%	Allen Bradley JA1N048S503MZ	1
R655	614-806327	Resistor, Var., Comp., 100k, 2W, 20%	Allen Bradley JA1N048S104MZ	5
R656 thru R659		Same as R655		
R660	607-801130	Resistor, F., Film, 33k, 1W, 1%	Inter. Res. DCF-33K-1%	1
TP650	683-806915	Jack, Tip	Whitso JNP-12	6
TP655 thru TP659		Same as TP650		

	855-402047	OSCILLATOR (Model 7350A)	Beckman	1
C401	633-804718	Capacitor, F., Ceramic, 0.01μf, 600V	Erie 811-.-1	4
C402	637-804777	Capacitor, F., Mica, 500pf, 500V	Sangamo RR1350	1
C403	637-804792	Capacitor, F., Mica, 1200pf, 500V	Sangamo KR1212	1
C404 thru C406	633-804673	Capacitor, F., Ceramic, 39pf, 600V	Erir NPO-332-390J	1
C407	637-804738	Capacitor, F., Mica, 15pf, 500V	Sangamo RR1415	1
C408		Same as C401		
C409	637-804761	Capacitor, F., Mica, 150pf, 500V	Sangamo RR1315	1
C410	647-804028	Capacitor, Var., Air, 2.3/14.2pf, 1250V	All Star MAPC-101	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
C411	631-815243	Capacitor, F., Elect., 5μf, 15Vdc	Barco P15-51	1
C412 & 413	633-804706	Capacitor, F., Ceramic, 0.001μf, 1000V, 20%	Centralab DD-102	2
C417	639-804871	Capacitor, F., Paper, 0.25μf, 200V	Hopkins P252D	1
CR401	755-409096	Diode, Selected, Type 1N198	Beckman	1
L402	795-807917	Inductor, F., R.F., 0.400mH	Wilco 1400-15	1
R401	601-010684	Resistor, F., Comp., 3.3k, 1/2W, 10%	Allen Bradley EB3321	1
R402	601-008096	Resistor, F., Comp., 56k, 1/2W, 10%	Allen Bradley EB5631	1
R403	601-800031	Resistor, F., Comp., 470Ω, 1/2W, 10%	Allen Bradley EB4711	2
R404	601-008083	Resistor, F., Comp., 3.9k, 1/2W, 10%	Allen Bradley EB3921	1
R405	601-008098	Resistor, F., Comp., 82k, 1/2W, 10%	Allen Bradley EB8231	1
R406	601-008080	Resistor, F., Comp., 2.2k, 1/2W, 10%	Allen Bradley EB2221	1
R407		Same as R403		
R408	601-007932	Resistor, F., Comp., 10k, 1/2W, 10%	Allen Bradley EB1031	1
R409	601-008866	Resistor, F., Comp., 2.2M, 1/2W, 10%	Allen Bradley EB2251	1
R410	601-002211	Resistor, F., Comp., 100k, 1/2W, 10%	Allen Bradley EB1041	1
R411	601-008074	Resistor, F., Comp., 680Ω, 1/2W, 10%	Allen Bradley EB6811	1
R412	601-008106	Resistor, F., Comp., 470k, 1/2W, 10%	Allen Bradley EB4741	2
R413	601-008092	Resistor, F., Comp., 22k, 1/2W, 10%	Allen Bradley EB2231	1
R414	614-806323	Resistor, Var., Comp., 50k, 2W, 20%	Allen Bradley JA1N048S503MZ	1
R415	601-008097	Resistor, F., Comp., 68k, 1/2W, 10%	Allen Bradley EB6831	1
R416	601-043207	Resistor, F., Comp., 6.8k, 1W, 10%	Allen Bradley GB6821	1
R417	601-008091	Resistor, F., Comp., 18k, 1/2W, 10%	Allen Bradley EB1831	1
R418		Same as R412		
S401	701-004254	Switch, SPST, Toggle	Cutler Hm. 8380K15	1
XV401 & XV402	860-802336	Socket, Tube, 9-pin, w/o Shield, w/Lugs	Elco 377BC	2
XY401	860-802333	Socket, Octal, Mica filled	Cinch Mfg. 16203	1

	855-402139	TIME BASE (Model 7360A)	Beckman	1
Same as for Model 7350A except for the following:				
Additions:				
C625	637-804741	Capacitor, F., Mica, 24pf, 500V, 5%	Sangamo RR1424	5
C626	633-804718	Capacitor, F., Ceramic, 0.01μf, 600V	Erie 811-.01	8
C627	637-807482	Capacitor, F., Mica, 10pf, 500V, 5%	Sangamo RR1410	6
C628	635-804930	Capacitor, F., Glass, 56pf, 500V, 5%	Vitramon CY13C560J-A	2
C629 & C630		Same as C626		
CR603	755-409096	Diode, Type 1N198, w/Point Contact	Beckman	3
CR604	755-818178	Diode, Germ., 100PIV, 4ma, 15V min. fwd. fwd.	Hughes 1N627	
Changes:				
R642	607-812008	Resistor, F., Film, 3.9 Meg., 1W, 1%	Electra DC-1-3.9M-1%	5
R645		Same as R642		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R648		Same as R642		
R651		Same as R642		
Deletions:				
R652 thru R654				
R661 & R662				
Additions:				
XV607 & XV608	860-802336	Socket, Tube, 9-Pin	Elco 377BC	8
	855-413454	SIGNAL GATE (Model 7360A)	Beckman	1
Same as for Model 7350A except for the following:				
Additions:				
C250	633-804717	Capacitor, F., Ceramic, 0.01μf, 500V	Sprague 29C9B5	4
C251	637-804777	Capacitor, F., Mica, 500pf, 500V, 5%	Sangamo RR1350	1
CR212 & 214	755-409096	Diode, Type 1N198, w/Point Contact	Beckman	3
L202	795-807870	Inductor, F., R. F., 0.0047mH	Wilco 213-115	1
L203	795-807877	Inductor, F., R. F., 0.0082mH	Wilco 216-117	1
L204	795-807879	Inductor, F., R. F., 0.010mH	Wilco 217-118	1
R269	601-015446	Resistor, F., Comp., 470Ω, 1/2W, 5%	Allen Bradley EB4715	1
R270	601-015038	Resistor, F., Comp., 1k, 1/2W, 5%	Allen Bradley EB1025	1
R271	601-800011	Resistor, F., Comp., 270Ω, 1/2W, 5%	Allen Bradley EB2715	1
R273	601-000897	Resistor, F., Comp., 2.2k, 1/2W, 5%	Allen Bradley EB2225	1
R274	601-015086	Resistor, F., Comp., 470k, 1/2W, 5%	Allen Bradley EB4745	2
R277	601-015052	Resistor, F., Comp., 10k, 1/2W, 5%	Allen Bradley EB1035	2
XV208	860-802323	Socket, Tube, 7-pin, Saddle Mtg. Min.	Elco 316BC	2
Changes:				
R229	601-015056	Resistor, F., Comp., 18k, 1/2W, 5%	Allen Bradley EB1835	1
R266	601-008129	Resistor, F., Comp., 1.5k, 1/2W, 5%	Allen Bradley EB1525	1
	855-402188	INPUT CHANNEL (Model 7360A)	Beckman	1
C907-1 & -2	637-807482	Capacitor, F., Mica, 10pf, 500V, 5%	Sangamo RR1410	2
C908-1 & -2	637-804744	Capacitor, F., Mica, 33pf, 500V, 5%	Sangamo RR1433	2
C909-1 & -2	637-804738	Capacitor, F., Mica, 15pf, 500V, 5%	Sangamo RR1415	2
C910-1 & -2	639-804871	Capacitor, F., Paper, 0.25μf, 200V	Hopkins P252D	2
C911-1 & -2	633-804718	Capacitor, F., Ceramic, 0.01μf, 600V	Erie 811-.01	2
C912-1 & -2	637-804768	Capacitor, F., Mica, 300pf, 500V, 5%	Sangamo RR1330	2
R907-1 & -2	601-017528	Resistor, F., Comp., 330k, 1/2W, 5%	Allen Bradley EB3345	2
R908-1 & -2	601-015449	Resistor, F., Comp., 1.8k, 1/2W, 5%	Allen Bradley EB1825	2
R909-1 & -2	601-010942	Resistor, F., Comp., 6.8k, 1/2W, 5%	Allen Bradley EB6825	4
R910-1 & -2		Same as R909-1		
R911-1 & -2	601-015044	Resistor, F., Comp., 8.2k, 1/2W, 5%	Allen Bradley EB8225	2
R912-1 & -2	601-015050	Resistor, F., Comp., 5.6k, 1/2W, 5%	Allen Bradley EB5625	2

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R913-1 & -2	601-008129	Resistor, F., Comp., 1.5k, 1/2W, 5%	Allen Bradley EB1525	2
R916-1 & -2	601-015077	Resistor, F., Comp., 120k, 1/2W, 5%	Allen Bradley EB1245	2
R917-1 & -2	601-015056	Resistor, F., Comp., 18k, 1/2W, 5%	Allen Bradley EB1835	4
R918-1 & -2	601-015079	Resistor, F., Comp., 150k, 1/2W, 5%	Allen Bradley EB1545	4
R919-1 & -2	601-015074	Resistor, F., Comp., 100k, 1/2W, 5%	Allen Bradley EB1045	4
R920-1 & -2	601-015052	Resistor, F., Comp., 10k, 1/2W, 5%	Allen Bradley EB1035	2
R921-1 & -2		Same as R918-1		
R922-1 & -2		Same as R919-1		
R923-1 & -2	601-043209	Resistor, F., Comp., 10k, 1W, 5%	Allen Bradley GB1035	2
R924-1 & -2	601-023764	Resistor, F., Comp., 3.9k, 1W, 5%	Allen Bradley GB3925	2
R925-1 & -2	601-022948	Resistor, F., Comp., 15k, 1/2W, 5%	Allen Bradley EB1535	2
R926-1 & -2		Same as R917-1		
T901-1 & -2	792-415436	Transformer, Pulse, 16 turns	Beckman	2
XV901-1 & -2	860-802336	Socket, Tube, 9-Pin, Saddle Mtg. Min.	Elco 377BC	6
XV902-1 & -2		Same as XV901-1		
XV903-1 & -2		Same as XV901-1		
XV904-1 & -2		Socket, Tube, Saddle Mtg. Min.	Elco 316BC	2
	855-402054	1 MC OSCILLATOR (Model 7360A)	Beckman	1
C401	633-804718	Capacitor, F., Ceramic, 0.01μf, 600V	Erie 811-.01	6
C402	637-804763	Capacitor, F., Mica, 180pf, 500V	Sangamo RR1318	1
C403	637-804771	Capacitor, F., Mica, 390pf, 500V, 5%	Sangamo RR1339	1
C404	633-812052	Capacitor, F., Ceramic, 56pf	Erie NPO-337-560J	1
C405 & C406		Same as C401		
C407	637-804738	Capacitor, F., Mica, 15pf, 500V	Sangamo RR1415	1
C408		Same as C401		
C409	637-804761	Capacitor, F., Mica, 150pf, 500V	Sangamo RR1315	1
C410	655-824658	Capacitor, Var., 0.6-14pf	JFD Elect. VC11GRA	1
C411	631-815243	Capacitor, Electrolytic, 5μf, 12V	Barco P15-51	1
C412 & C413	633-804706	Capacitor, F., Ceramic, 0.001μf	Centralab DD-102	2
C414	637-819113	Capacitor, F., Mica, 100pf, 500V, 5%	Sangamo RR5E101J03	1
C415 & C416		Same as C401		
CR401	755-409086	Diode, Type 1N198	Beckman	1
L401 & L402	795-807912	Inductor, F., R.F., 0.240mH	Wilco 3240-15	2
R401	601-010684	Resistor, F., Comp., 3.3k, 1/2W, 10%	Allen Bradley EB3321	1
R402	601-008096	Resistor, F., Comp., 56k, 1/2W, 10%	Allen Bradley EB5631	1
R403	601-800031	Resistor, F., Comp., 470Ω, 1/2W, 10%	Allen Bradley EB4711	2
R404	601-008083	Resistor, F., Comp., 3.9k, 1/2W, 10%	Allen Bradley EB3921	1
R405	601-008098	Resistor, F., Comp., 82k, 1/2W, 10%	Allen Bradley EB8231	1
R406	601-008080	Resistor, F., Comp., 2.2k, 1/2W, 10%	Allen Bradley EB2221	1
R407		Same as R403		
R408	601-007932	Resistor, F., Comp., 10k, 1/2W, 10%	Allen Bradley EB1031	1
R409	601-008866	Resistor, F., Comp., 2.2M, 1/2W, 10%	Allen Bradley EB2251	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R410	601-002211	Resistor, F., Comp., 100k, 1/2W, 10%	Allen Bradley EB1041	1
R411	601-008074	Resistor, F., Comp., 680Ω, 1/2W, 10%	Allen Bradley EB6811	1
R412	601-800033	Resistor, F., Comp., 680k, 1/2W, 10%	Allen Bradley EB6841	1
R413	601-008092	Resistor, F., Comp., 22k, 1/2W, 10%	Allen Bradley EB2231	1
R414	614-806323	Resistor, V., Comp., 50k, 2W, 20%	Allen Bradley JA1N048S503MZ	1
R415	601-008097	Resistor, F., Comp., 68k, 1/2W, 10%	Allen Bradley EB6831	1
R416	601-043207	Resistor, F., Comp., 6.8k, 1W, 10%	Allen Bradley GB6821	1
R417	601-008091	Resistor, F., Comp., 18k, 1/2W, 10%	Allen Bradley EB1831	1
R418	601-008106	Resistor, F., Comp., 470k, 1/2W, 10%	Allen Bradley EB4741	1
S401	701004254	Switch, Toggle, SPST, 3 Amp at 250V ac	Cutler Ham. 8380K15	1
XV401 & XV402	860-802336	Socket, Tube, 9-Pin, Saddle Mtg. Min.	Elco 377BC	2
XY401	860-802333	Socket, Tube, 8-Pin, Saddle Mtg. Min.	Cinch Mfg. 16203	1

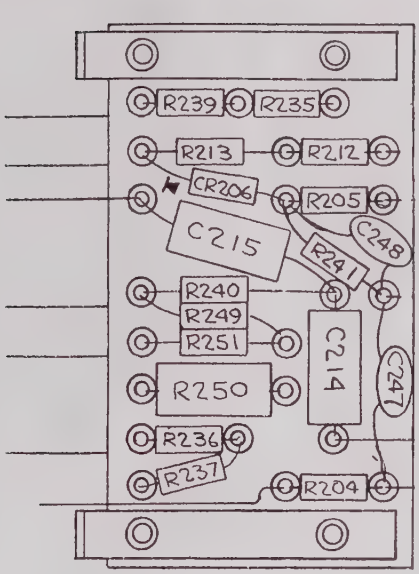
MISCELLANEOUS - MODELS 7350A & 7360A

Decimal Counting Units (DCU's):				
A201	887-402847	Model 775AJ DCU	Beckman	1
A202	887-402849	Model 775 DCU	Beckman	4
A203 thru A205		Same as A202		
A206	887-402934	Model 785 DCU	Beckman	1
A207*	887-402915	Model 795 DCU	Beckman	1
Components:				
F101 & F102	731-801574	Fuse, Electrical, 3 Amps, 125V, Time Delay	Littelfuse 313003	2
F101 & * F102	731-023753	Fuse, 4 Amp, Slo Blo	Littelfuse 312004	2
I101 & I401	825-063063	Lamp, Incandescent, Min. Bayonet Base	Gen. Elect. #47	2
J301-1 & J301-2	670-806738	Connector, Coaxial, Receptacle, BNC type	Amphenol UG-1094/U	2
R114	604-802000	Resistor, F., W.W., 1k, 10W, 10%	Tru-Ohm FRL-10-1K-10%	1
R247	614-817612	Resistor, V. Comp., 10M, w/Switch	Centralab BA-826-006	1
R248	601-015064	Resistor, F., Comp., 47k, 1/2W, 5%	Allen Bradley EB4735	1
R318-1 & R318-2	614-812445	Resistor, V., Comp., 10k, 2W, 10%	Allen Bradley JA1N048S103MZ-T	2
R418*	601-800184	Resistor, F., Comp., 68k, 2W, 10%	Allen Bradley HB6831	1
S101	701-806031	Switch, Toggle, DPST	Cutler Ham. 8370K8	1
S202 & S203	701-806040	Switch, Toggle, DPDT	Cutler Ham. 8373K8	2
S204*		Part of R247		
S205	704-043278	Switch, Pushbutton, SPDT	Switchcraft 203	1

*Model 7360A

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
T101	792-402952	Transformer, Power	Beckman	1
V101	751-015096	Electron Tube, Type 6AU6	RCA 6AU6	1
V102	751-020285	Electron Tube, Type 6080	RCA 6080	
V202 & V203	751-800258	Electron Tube, Type 5965	RCA 5965	15
V204	751-800223	Electron Tube, Pentode, Type 6AS6	RCA 6AS6	1
V205		Same as V202		
V206	751-800237	Electron Tube, Duotriode, Type 6DJ8	Amperex 6DJ8	1
V207		Same as V202		
V208**	751-800221	Electron Tube, Pentode, Type 6AK5	RCA 6AK5	1
V301-1 & V301-2		Same as V202		
V302-1 & V302-2		Same as V202		
V303-1 & V303-2*	751-800240	Electron Tube, Combination, Type 6U8	G. E. 6U8	5
V401 & V402*		Same as V303-1		
V602 & V603*		Same as V202		
V401 & V402**	751-800240	Electron Tube, Type 6U8	G. E. 6U8	3
V601**		Same as V401		
V602 thru V606*		Same as V202		
V607 & V608**		Same as V202		
V903-1 & V903-2**	751-800261	Electron Tube, 6350	Sylvania 6350	2
V904-1 & V904-2**	751-079164	Electron Tube, 6AH6	Raytheon 6AH6	2
XI101	824-801191	Lamp Socket, w/Green Lens	Dialight 81410-432	1
XI401*	824-801193	Lampholder, w/Red Lens	Drake 101-RED	1
XI401**	824-808238	Lamp Socket, w/Red Lens	Dialight 81410-431	1
Y401*	881-403435	Crystal, 100kc, Heated w/Octal Plug	Beckman	1
Y401**	881-430340	Crystal & Oven Assembly, 1 Mc	Beckman	1
	325-802714	Knob, Black, Plastic, 3/4" Dia.	Kurz-Kasch S-645-3BBL	1
	325-814762	Knob, Bar, Black 1-1/8"	Kurz-Kasch S-657-3BBL	4
	330-007514	Handle	USECO 1020	2
	325-802713**	Knob, Black, Plastic, 1" Dia.	Kurz-Kasch S-647-3BBL	2

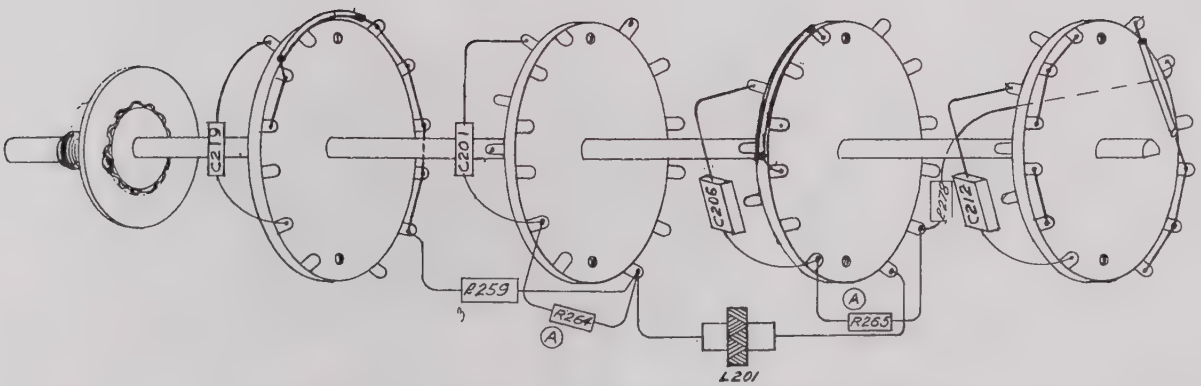
*Model 7350A.
**Model 7360A.



RESET COMPONENT LAYOUT
(Models 7350A & 7360A)

7350A & 7360A
B 401723-Rev B
January 1967

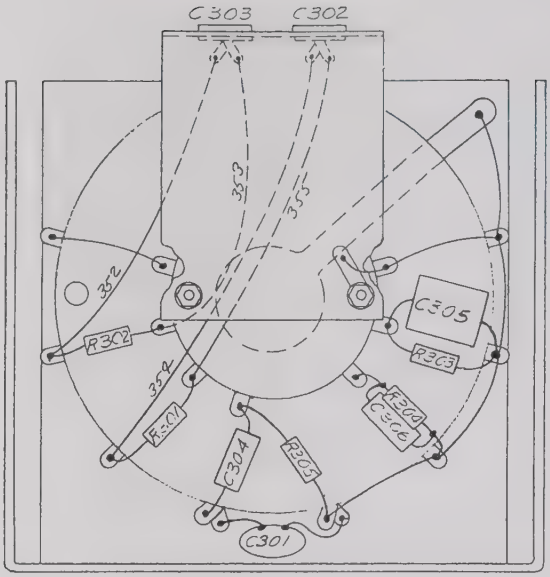
Beckman



MODELS 7350A & 7360A FUNCTION SWITCH COMPONENT LAYOUT

7350A & 7360A
C 402215-Rev. F
January 1967

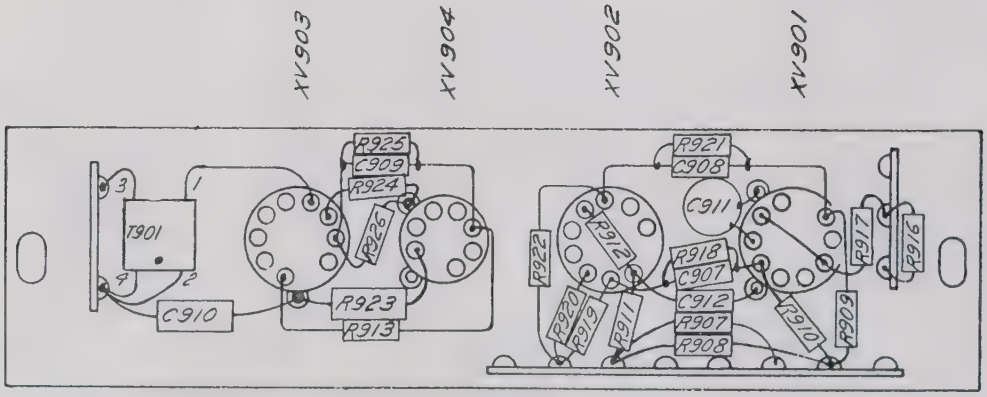
Beckman



MODELS 7350A & 7360A
ATTENUATOR SWITCH COMPONENT LAYOUT

7350A & 7360A
A 401683-Rev. A
January 1967

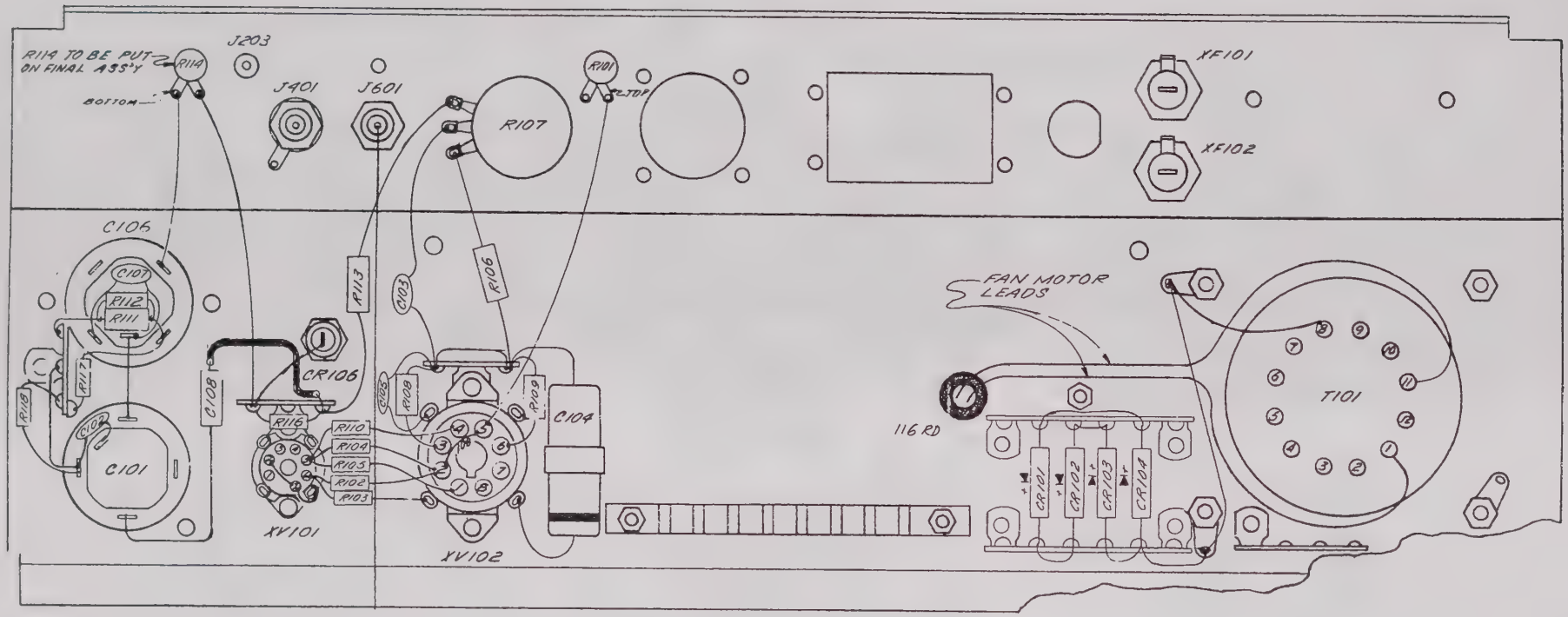
Beckman



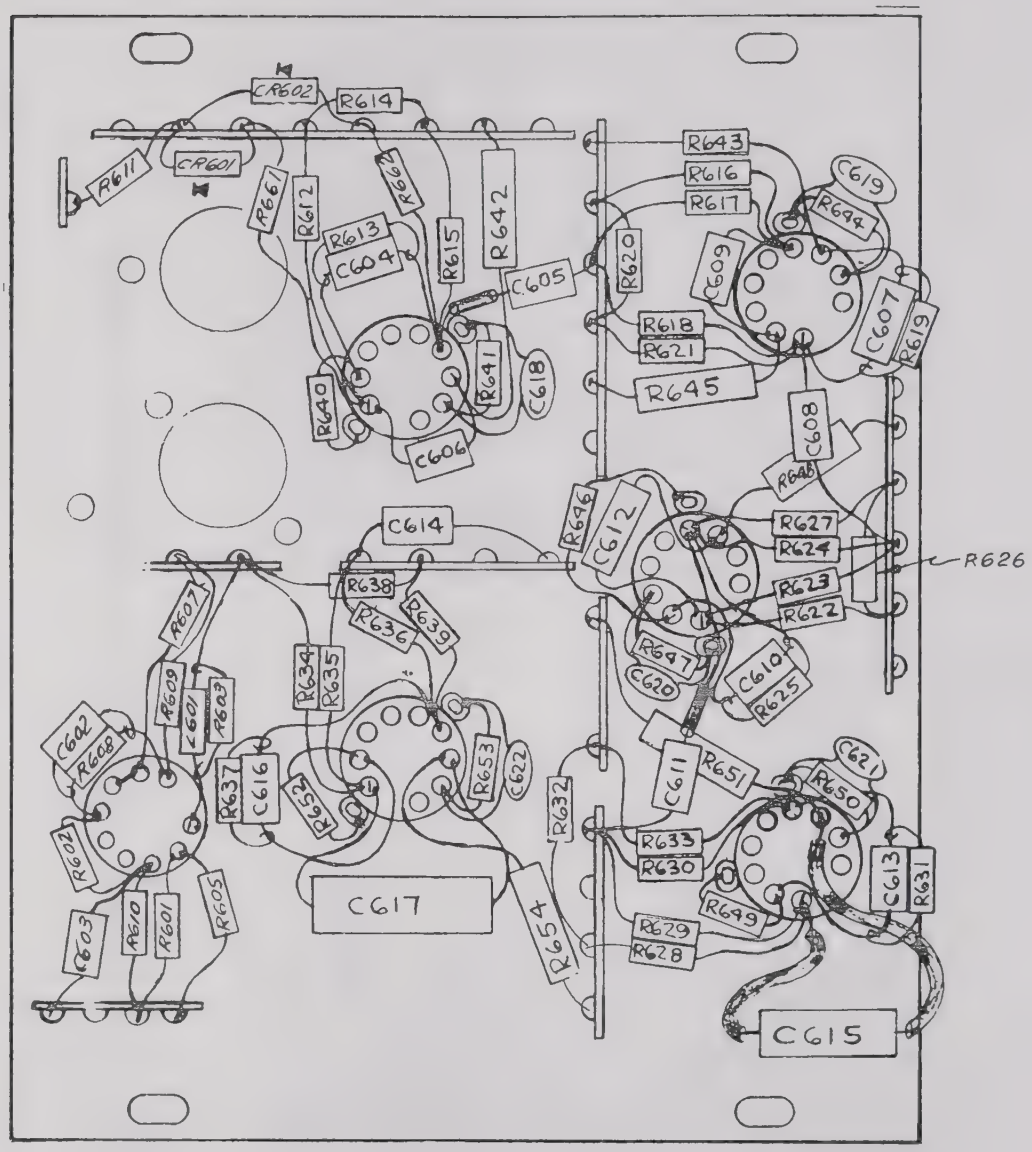
MODEL 7360A "A" OR "B" INPUT CHANNEL
COMPONENT LAYOUT

7350A & 7360A
B 402188-Rev. I
January 1967

Beckman

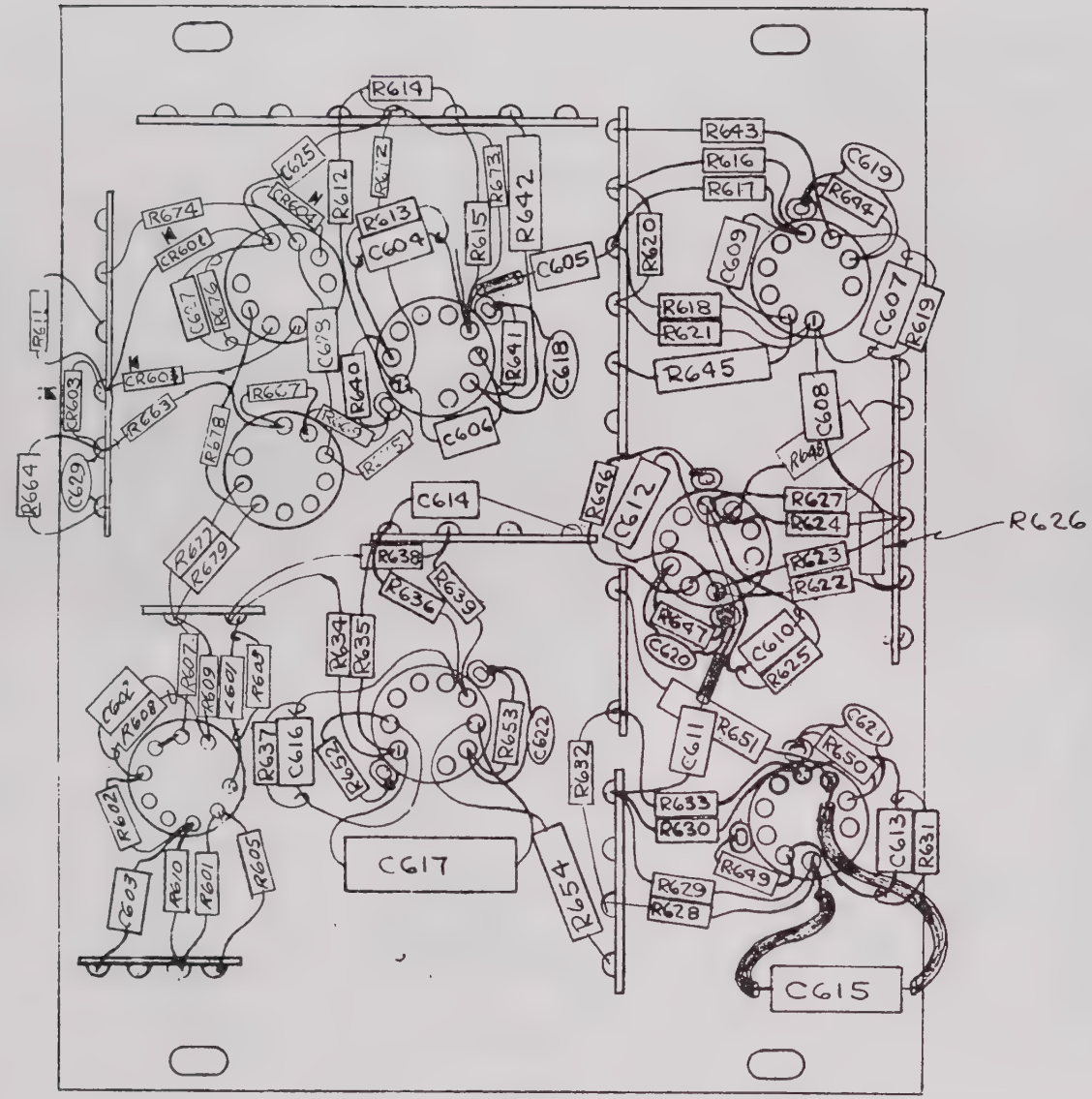


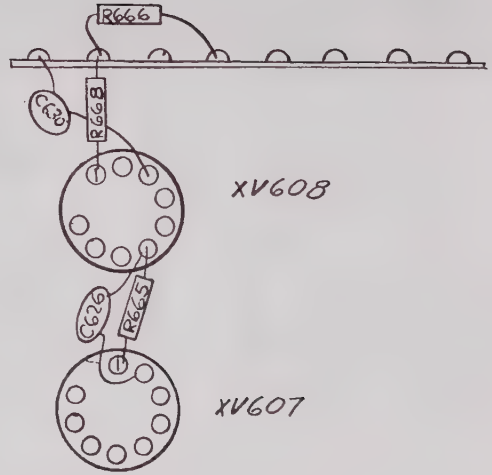
MODELS 7350A & 7360A POWER SUPPLY COMPONENT LAYOUT



MODEL 7350A TIME BASE COMPONENT LAYOUT

Beckman



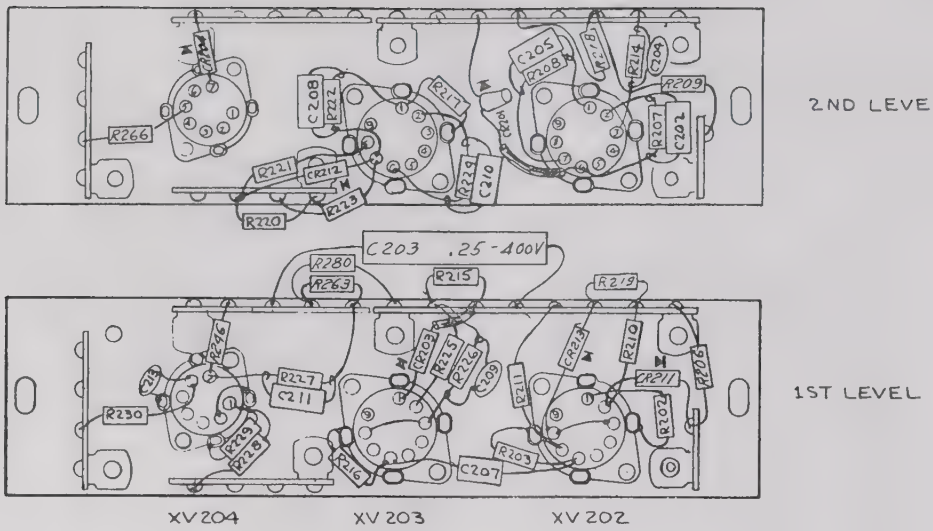


ADDITIONAL COMP.

MODEL 7360A TIME BASE COMPONENT LAYOUT

7350A & 7360A
C 402139-Rev. E
January 1967

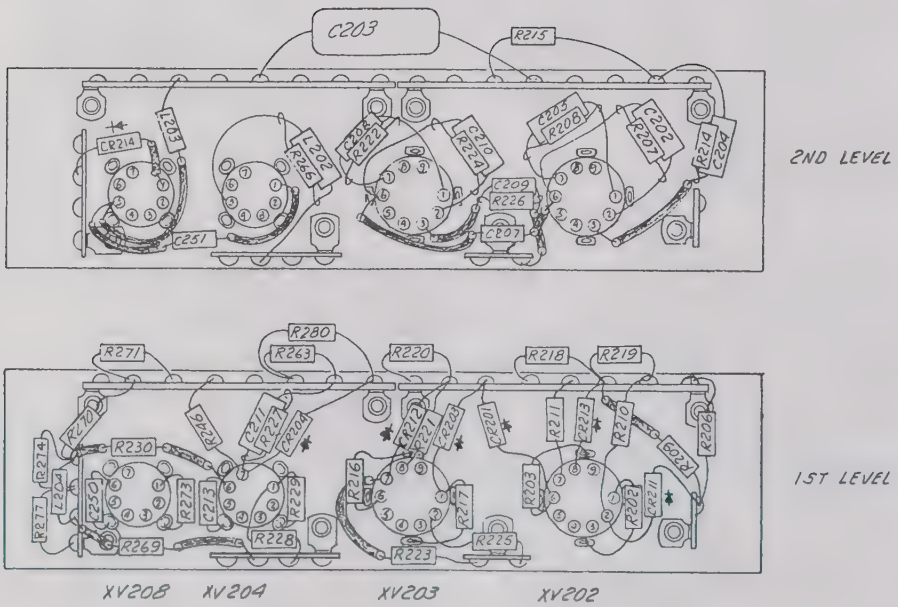
Beckman



MODEL 7350A SIGNAL GATE COMPONENT LAYOUT

7350A & 7360A
B401693-Rev. D
January 1967

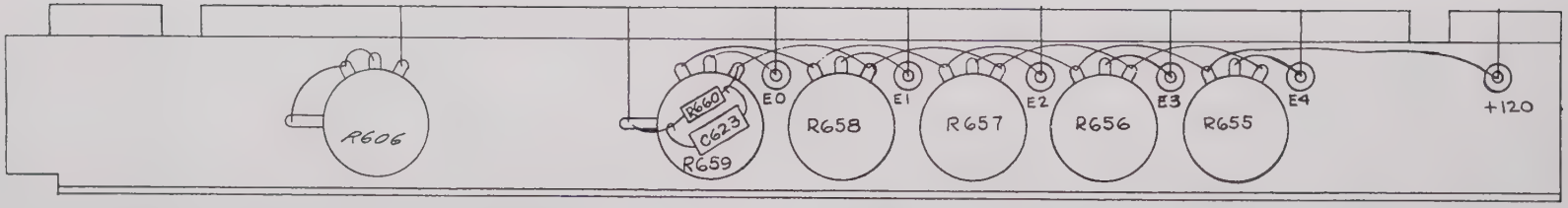
Beckman



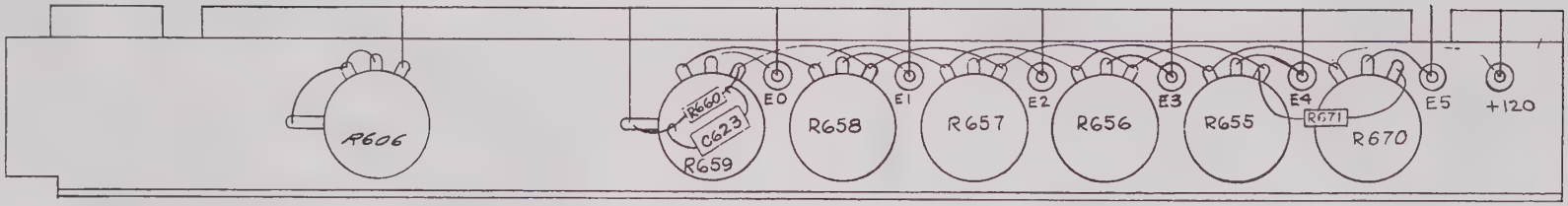
MODEL 7360A SIGNAL GATE COMPONENT LAYOUT

7350A & 7360A
B413454-Rev. F
January 1967

Beckman

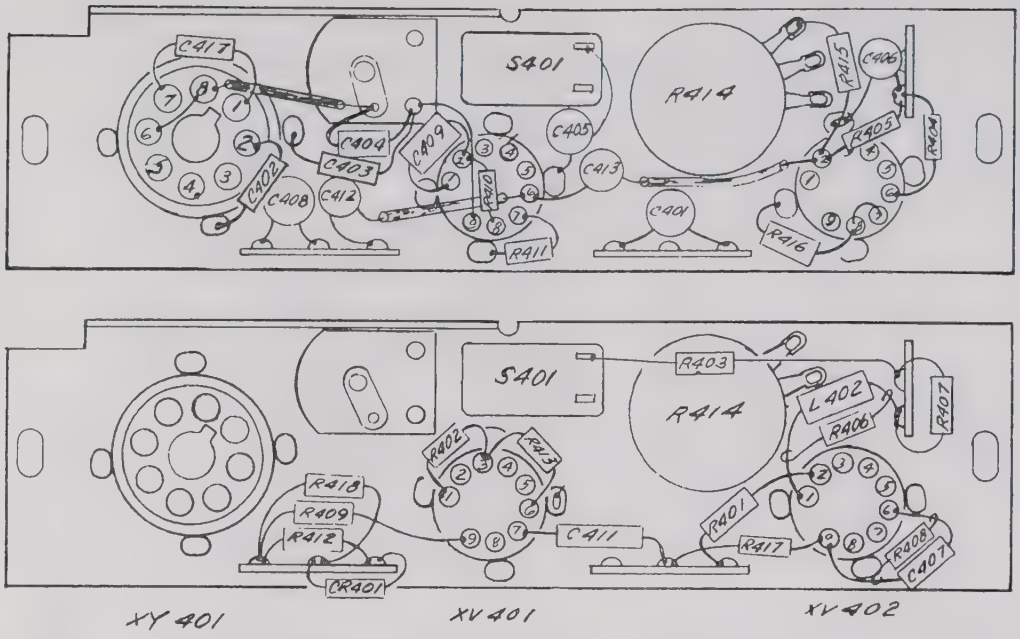


MODEL 7350A POT BRACKET COMPONENT LAYOUT



MODEL 7360A POT BRACKET COMPONENT LAYOUT

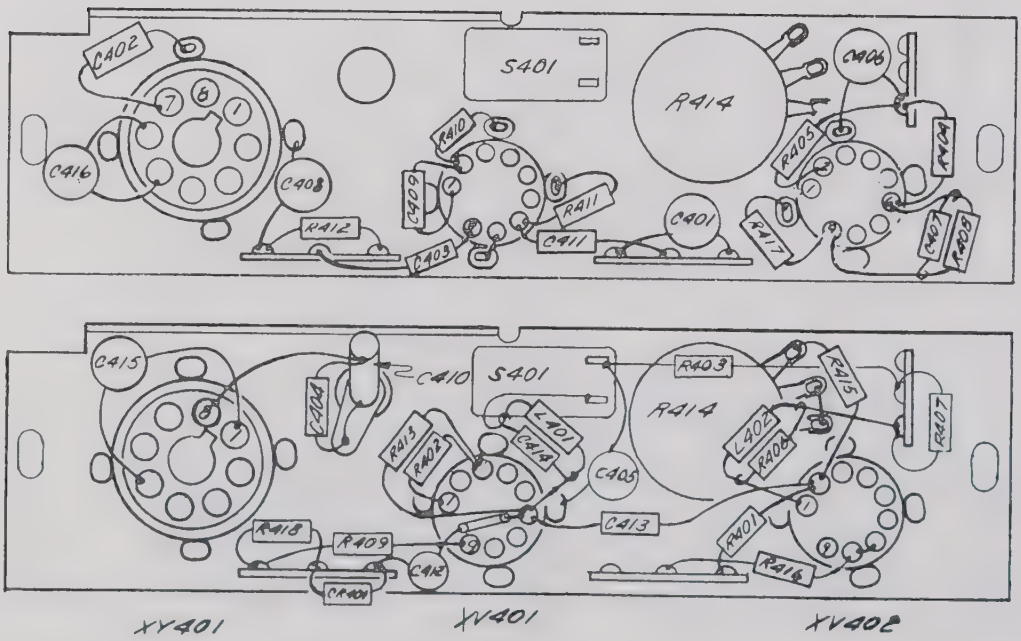
7350A & 7360A
C 402146-Rev. B
January 1967



MODEL 7350A 100 KC OSCILLATOR COMPONENT LAYOUT

7350A & 7360A
B 402047-Rev. E
January 1967

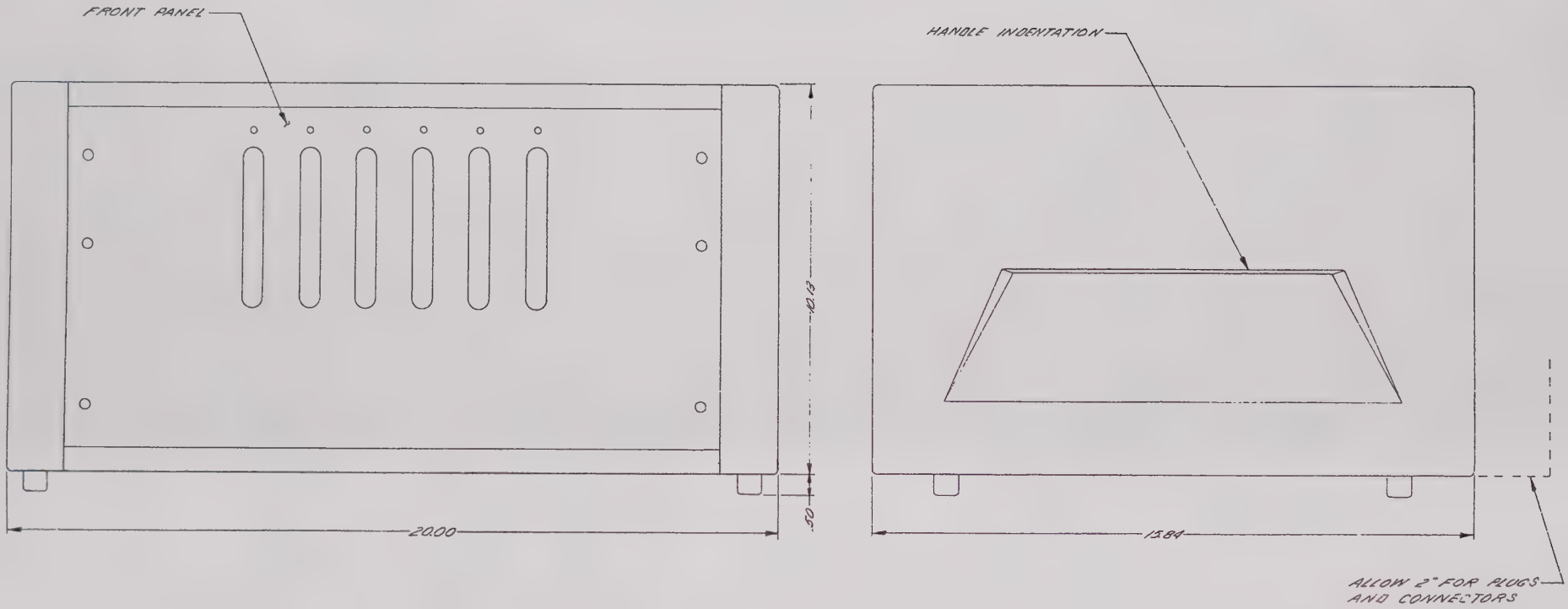
Beckman



MODEL 7360A 1 MC OSCILLATOR COMPONENT LAYOUT

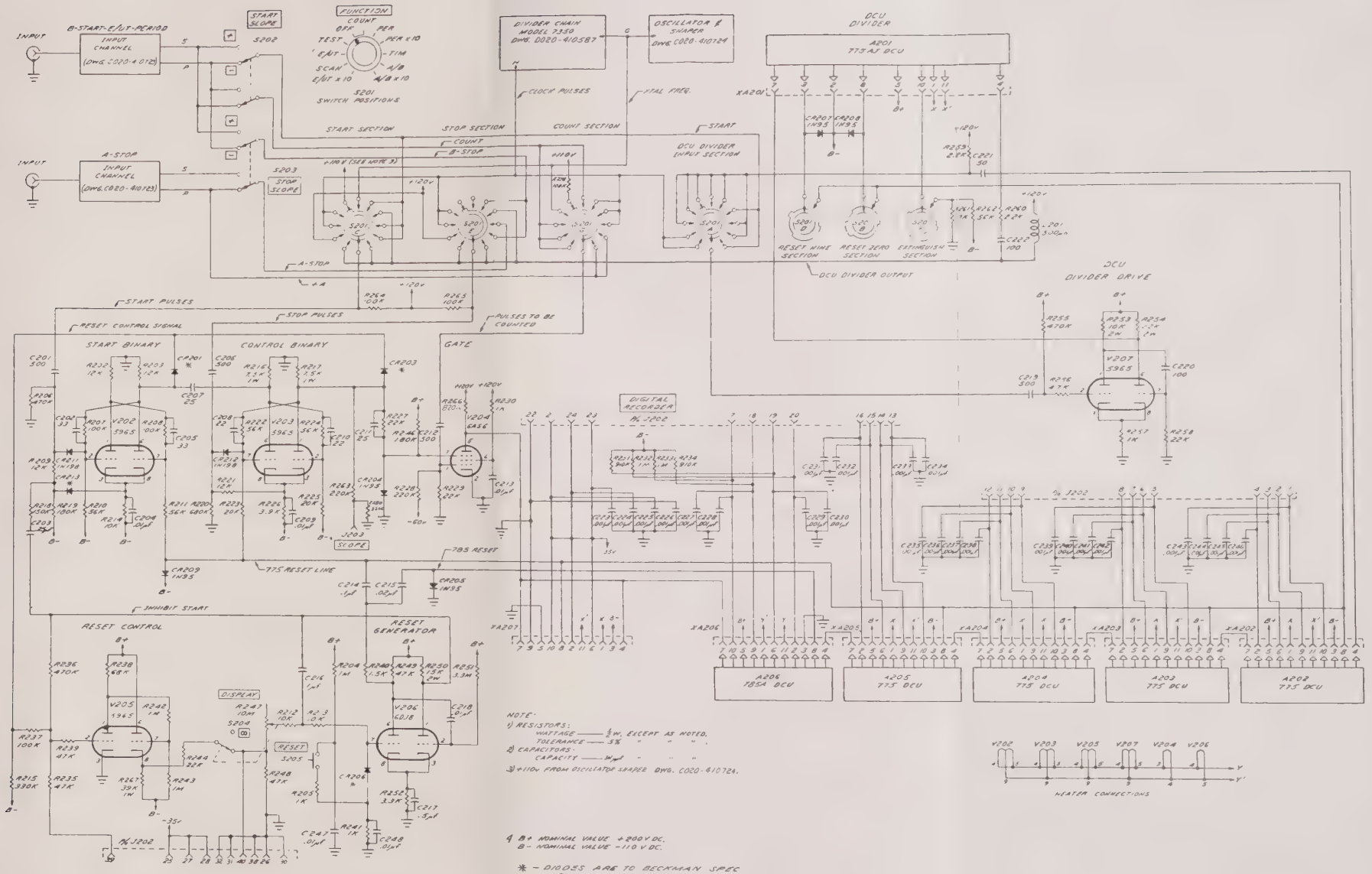
7350A & 7360A
B 402054-Rev C
January 1967

Beckman

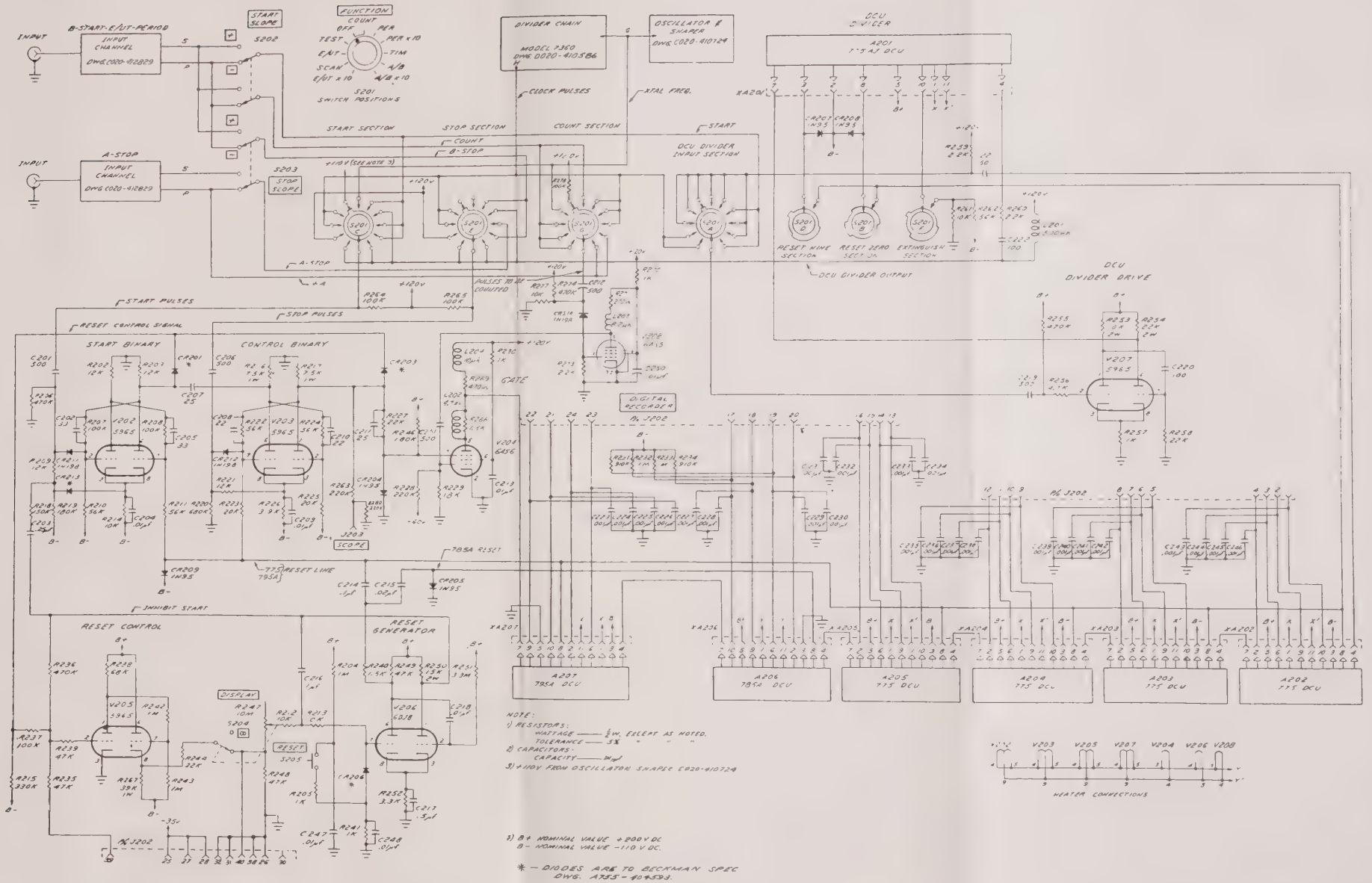


OUTLINE DRAWING

Beckman
7350A & 7360A
C-40191-Rev. A
January 1967


INPUT
B-START-E/UT-PERIOD
INPUT CHANNEL
(DWG. C020-4 012)
A-STOP
INPUT CHANNEL
(DWG. C020-410723)
START SLOPE
STOP SLOPE
FUNCTION
COUNT OFF
TEST
E/UT
SCAN E/UT x10
PER
PER x10
TIM
A/B
A/B x10
S201 SWITCH POSITIONS
DIVIDER CHAIN MODEL 7350 DWG. D020-410587
OSCILLATOR & SHAPER DWG. C020-410724
DCU DIVIDER
A201 775 AJ DCU
CLOCK PULSES
XTAL FREQ.
START SECTION
STOP SECTION
COUNT SECTION
START
COUNT
B-STOP
A-STOP
DCU DIVIDER INPUT SECTION
RESET WIRE SECTION
RESET ZERO SECTION
EXTINGUISH SECTION
DCU DIVIDER OUTPUT
DCU DIVIDER DRIVE
START PULSES
STOP PULSES
PULSES TO BE COUNTED
RESET CONTROL SIGNAL
START BINARY
CONTROL BINARY
GATE
DIGITAL RECORDER
INHIBIT START
RESET CONTROL
RESET GENERATOR
DISPLAY
RESET
775 RESET LINE
785 RESET
SLOPE
A206 785A DCU
A205 775 DCU
A204 775 DCU
A203 775 DCU
A202 775 DCU
NOTE:
1) RESISTORS:
WATTAGE — ½W, EXCEPT AS NOTED.
TOLERANCE — 5% " " " ".
2) CAPACITORS:
CAPACITY — MFD " " " ".
3) +110v FROM OSCILLATOR SHAPER DWG. C020-410724.
4 B+ NOMINAL VALUE +200V DC.
B- NOMINAL VALUE -110 V DC.
* - DIODES ARE TO BECKMAN SPEC DWG. A755-407593.
V202 V203 V205 V207 V204 V206
HEATER CONNECTIONS

Beckman


INPUT
B-START-E/UT-PERIOD
INPUT CHANNEL
DWG C020-412829
A-STOP
START SLOPE
STOP SLOPE
S202
S203
FUNCTION
COUNT
OFF
PER
TEST
PER x10
E/UT
TIM
SCAN
N/B
E/UT x10
N/B x10
S201
SWITCH POSITIONS
DIVIDER CHAIN
MODEL 7360
DWG 0020-410586
OSCILLATOR & SHAPER
DWG C020-410724
DCU DIVIDER
A201
7-5 A/ DCU
CLOCK PULSES
XTAL FREQ.
START SECTION
STOP SECTION
COUNT SECTION
START
COUNT
B-STOP
A-STOP
DCU DIVIDER INPUT SECTION
RESET NINE SECTION
RESET ZERO SECTION
EXTINGUISH SECTION
DCU DIVIDER OUTPUT
DCU DIVIDER DRIVE
START PULSES
STOP PULSES
RESET CONTROL SIGNAL
START BINARY
CONTROL BINARY
GATE
DIGITAL READOUT
INHIBIT START
RESET CONTROL
RESET GENERATOR
DISPLAY
RESET
SCOPE
785A RESET
775 RESET LINE
785A
775
A207 785A DCU
A206 785A DCU
A205 775 DCU
A204 775 DCU
A203 775 DCU
A202 775 DCU
HEATER CONNECTIONS
NOTE:
1) RESISTORS:
WATTAGE — ½W, EXCEPT AS NOTED.
TOLERANCE — 5% " " "
2) CAPACITORS:
CAPACITY — MFD
3) +110V FROM OSCILLATOR SHAPER C020-410724
4) B+ NOMINAL VALUE +200 V DC
B- NOMINAL VALUE -110 V DC.
* — DIODES ARE TO BECKMAN SPEC DWG. 473S-409593.

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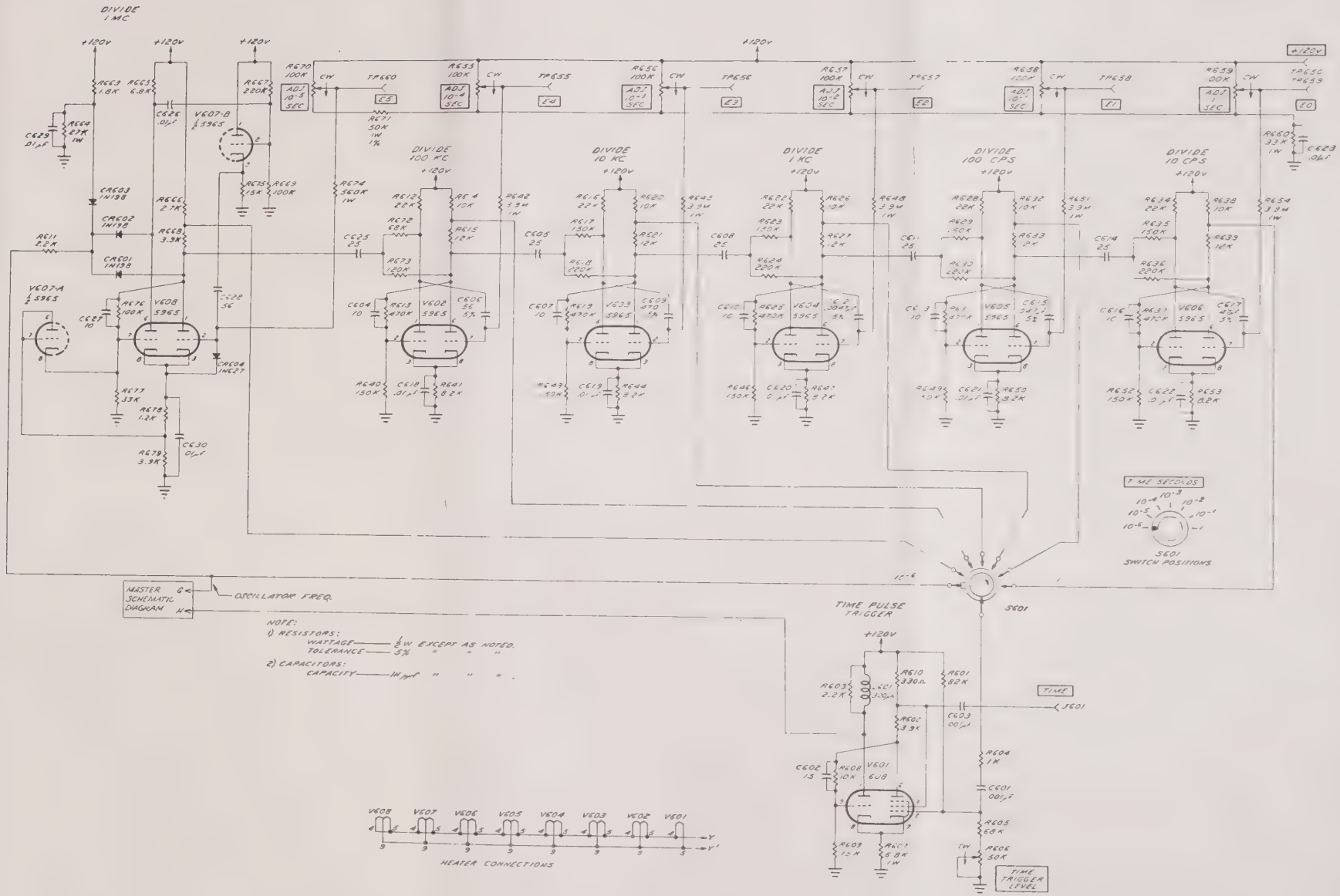
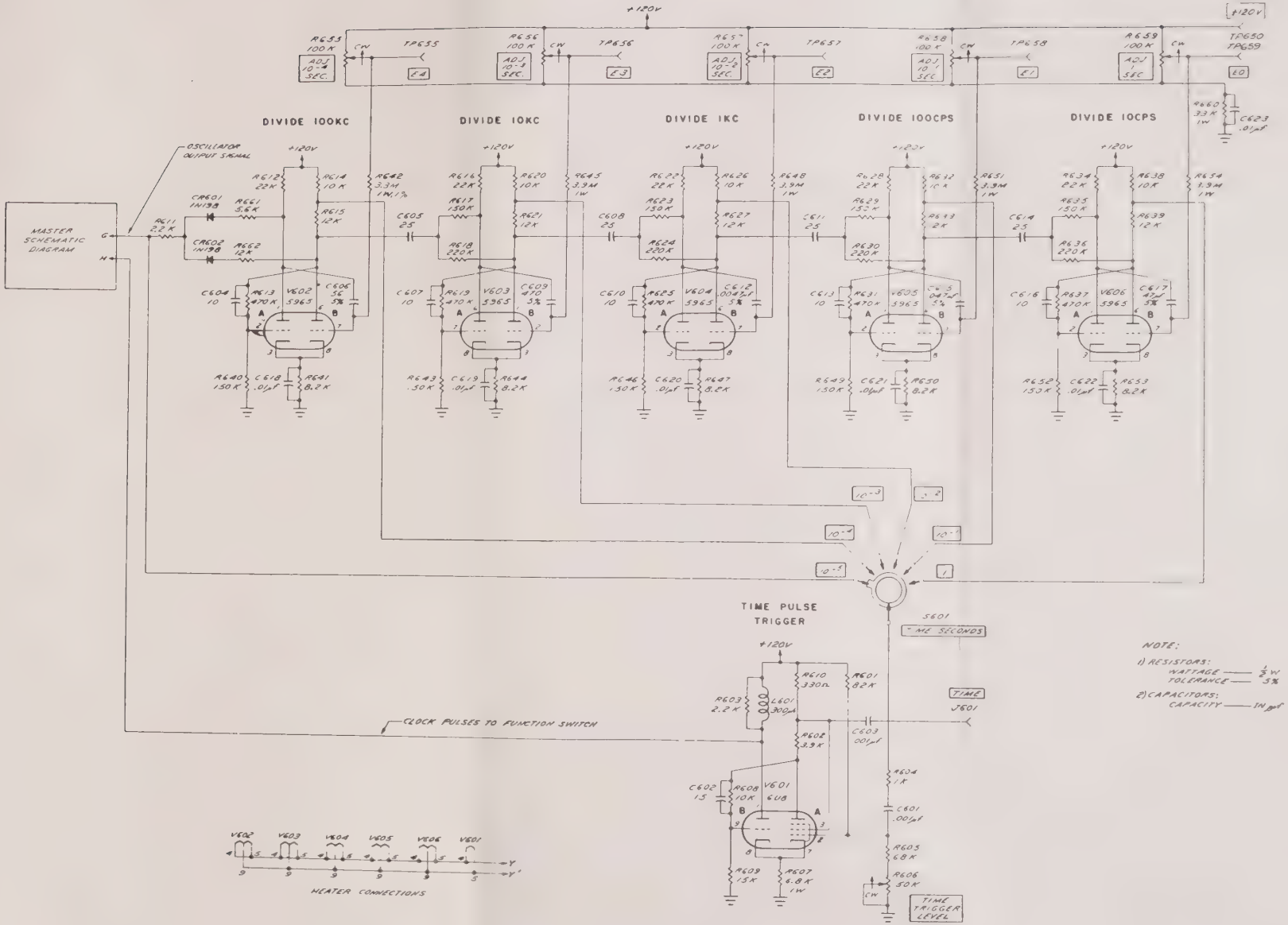
MODEL 7360A
1 MC DIVIDER CHAIN
SCHEMATIC DIAGRAM



7350A & 7360A
D410586-Rev. B
January 1967

Beckman

MODEL 7350A
100 KC DIVIDER CHAIN
SCHEMATIC DIAGRAM



NOTE:
1) RESISTORS:
WATTAGE —— ½ W EXCEPT AS NOTED.
TOLERANCE —— 5% " " " .
2) CAPACITORS:
CAPACITY —— IN μf " " " " .

7350A & 7360A
D 410587-Rev. A
January 1967

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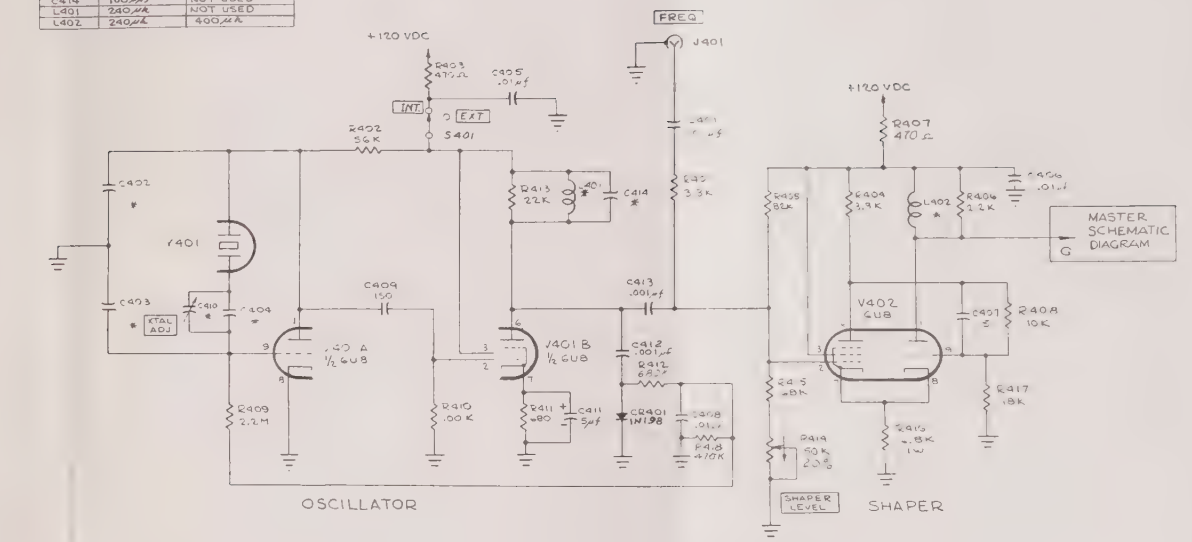
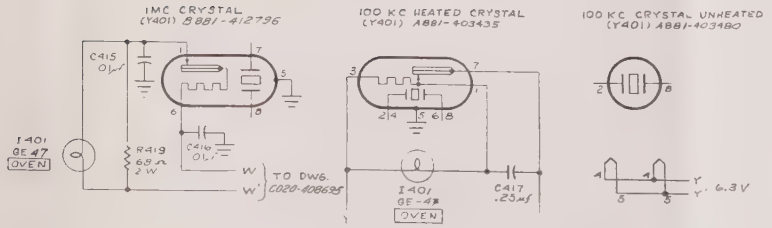
OSCILLATOR & SHAPER SCHEMATIC DIAGRAM

*COMPONENT VALUES ARE AS LISTED BELOW

COMP.	WITH 1 MC XTAL	WITH 100 KC XTAL
C402	180 μμf	500 μμf
C403	390 μμf	1200 μμf
C409	56 μμf (NOM.)	39 μμf (NOM.)
C410	.6-14 pf	100 μμf VAR.
C414	100 μμf	NOT USED
L401	240 μh	NOT USED
L402	240 μh	400 μh

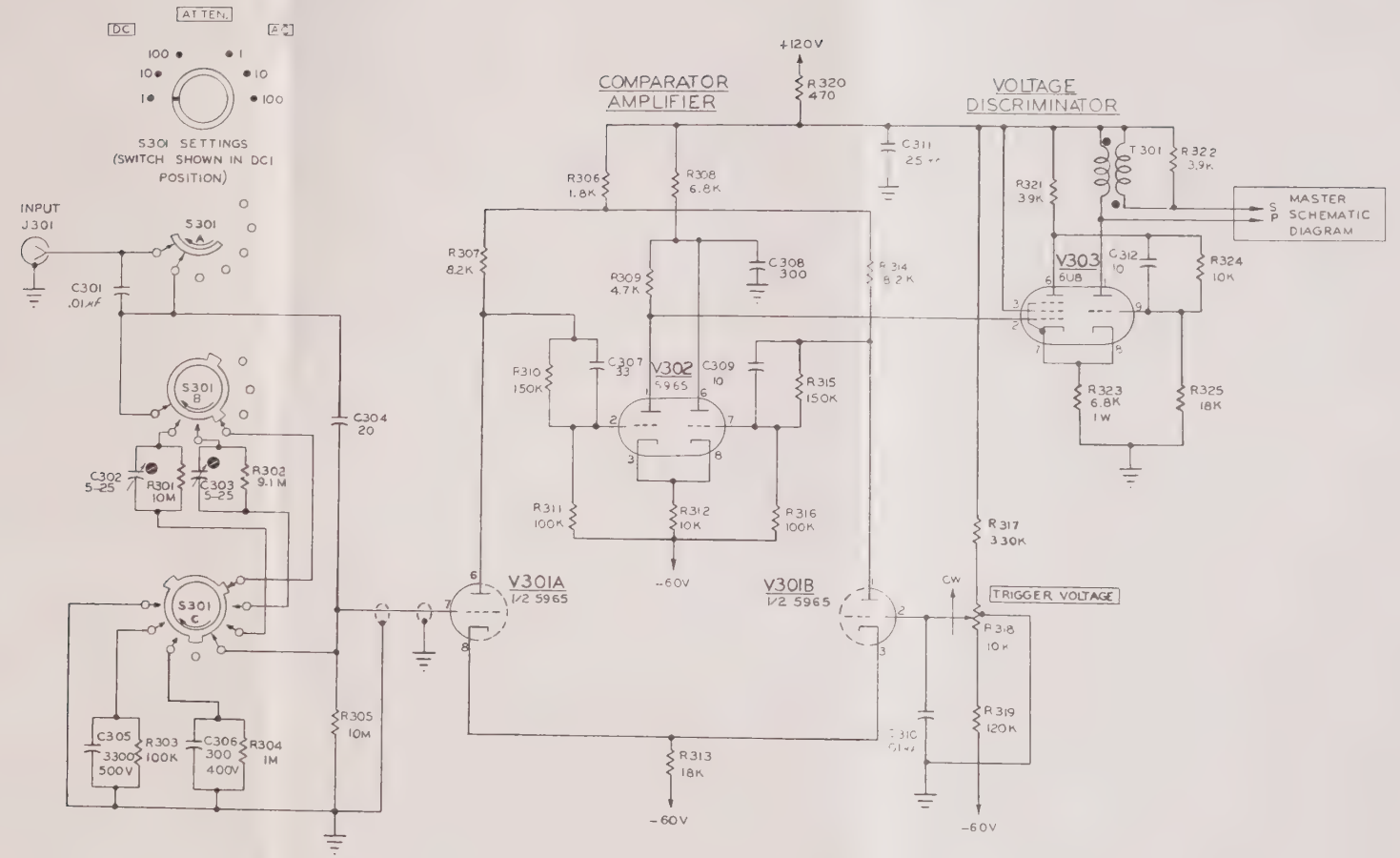


NOTE:
1. RESISTORS:
   WATTAGE - ½W UNLESS OTHERWISE NOTED
   TOLERANCE - 10% " "
2. CAPACITORS:
   CAPACITY - IN μμf UNLESS OTHERWISE NOTED

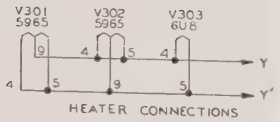


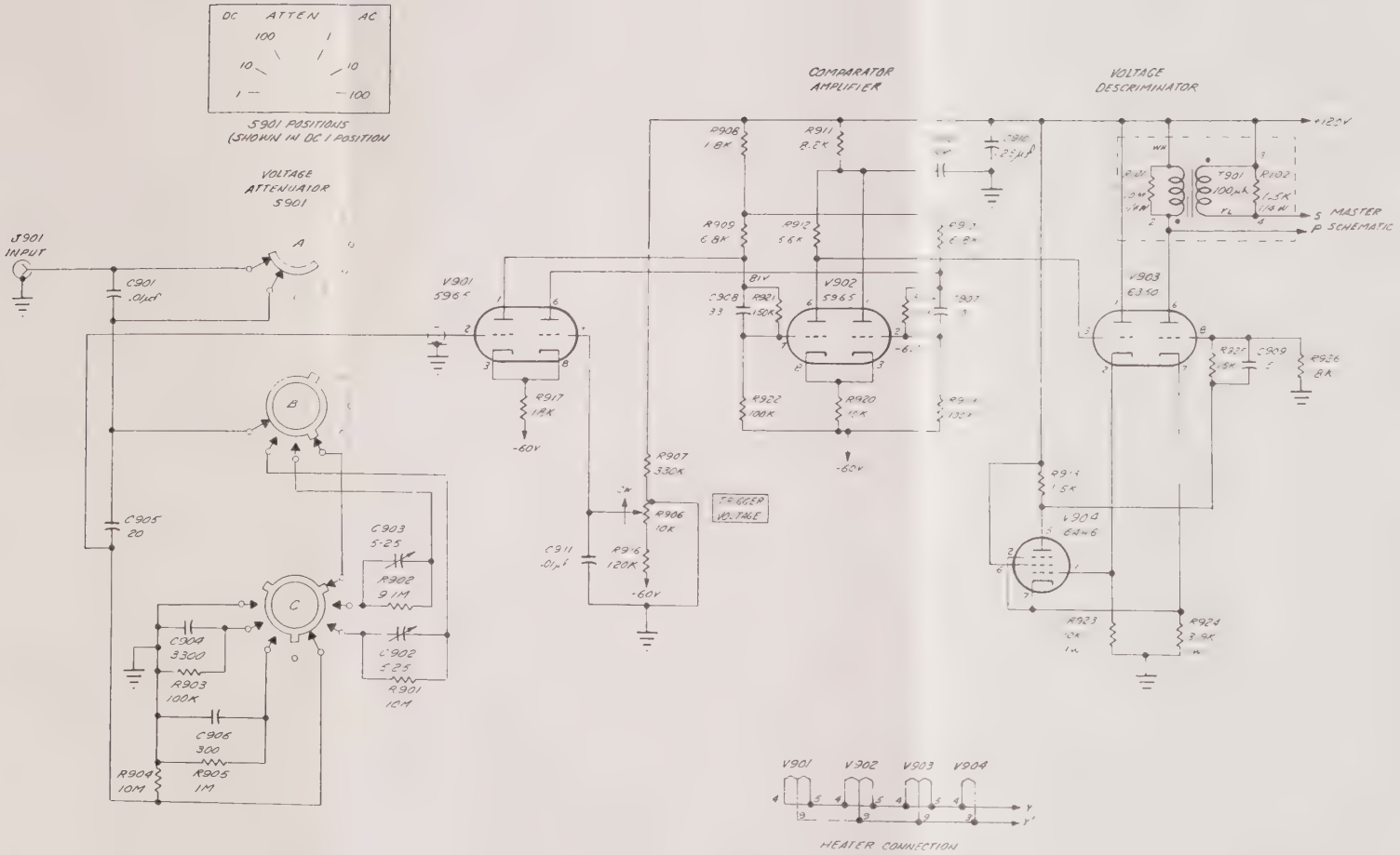
7350 & 7360
C410724-Rev. L
December 1966

Beckman



NOTES:
1. UNLESS OTHERWISE NOTED:
RESISTORS ARE 1/2 W, 5%
CAPACITOR VALUES ARE IN μμf





NOTES:
1) RESISTORS:
WATTAGE 1/2W EXCEPT AS NOTED.
TOLERANCE 5% " " " "
2) CAPACITORS:
CAPACITY IN μμf " " " "

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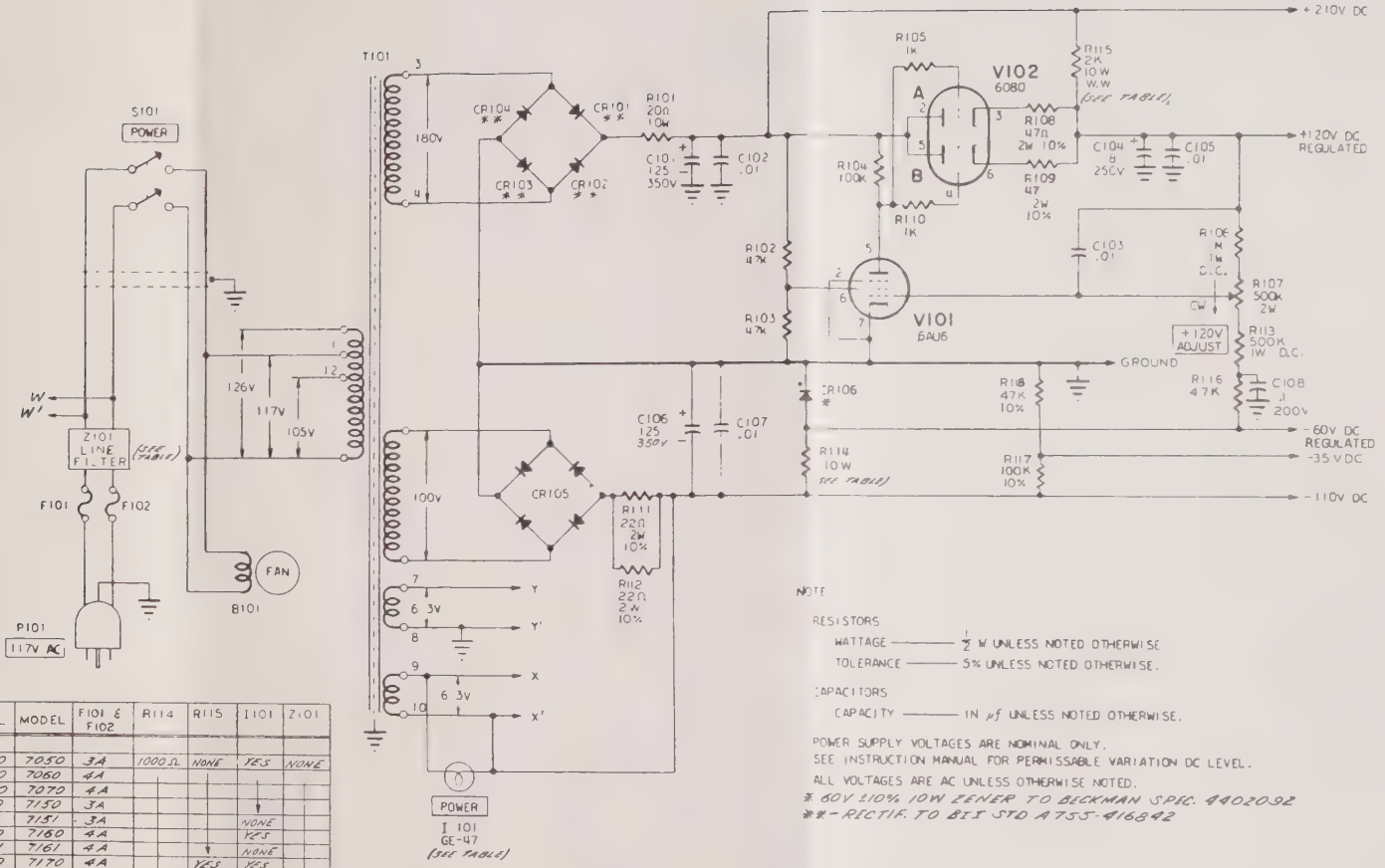
POWER SUPPLY
SCHEMATIC DIAGRAM



MODEL	MODEL	F101 & F102	R114	R115	I101	Z101
8050	7050	3A	1000Ω	NONE	YES	NONE
8060	7060	4A				
8070	7070	4A				
8150	7150	3A				
8151	7151	3A			NONE	
8160	7160	4A			YES	
8161	7161	4A			NONE	
8170	7170	4A		YES	YES	
8250	7250	3A		NONE		
8260	7260	4A				
8270	7270	4A	620Ω	YES		
8350	7350	3A	1000Ω	NONE		
8351	7351	3A			NONE	
8360	7360	4A			YES	
8361	7361	4A			NONE	
8370	7370	4A	600Ω	YES	YES	
	5571	4A	1000Ω	NONE		YES
	7413/16	4A				
	7417/18	4A				
	7555/57	3A			NONE	NONE

HEATER CONNECTIONS

NOTE

RESISTORS
WATTAGE ——— ½ W UNLESS NOTED OTHERWISE
TOLERANCE ——— 5% UNLESS NOTED OTHERWISE.

CAPACITORS
CAPACITY ——— IN μf UNLESS NOTED OTHERWISE.

POWER SUPPLY VOLTAGES ARE NOMINAL ONLY.
SEE INSTRUCTION MANUAL FOR PERMISSABLE VARIATION DC LEVEL.
ALL VOLTAGES ARE AC UNLESS OTHERWISE NOTED.
* 60V ±10% 10W ZENER TO BECKMAN SPEC. 44020-92
** - RECTIF. TO BEI STD A755-416842

7350 & 7360
C 408695-Rev Q
December 1966

Beckman®

Supplementary Service Notes, SSN7000

Introduction. These notes cover recommended methods of servicing any instrument in the BECKMAN/Berkeley 7000 Series. This includes Models 7050, 7060, 7150, 7160, 7250, 7360, and the counter portion of Model 5571. Some of these instruments do not contain all the major components treated below (for example, Models 7250 and 7260 do not contain a frequency dividing chain); therefore, ignore inapplicable references.

Training and Experience Required. Any person who knows basic electronics and has used a scope and vacuum-tube voltmeter should not hesitate to undertake the repair of a Beckman counting instrument. Short of actual factory training, reading the instruction manual is the best way to familiarize oneself with the instrument. A detailed study of the schematics will yield additional knowledge, and, studied along with an actual instrument removed from the cabinet, will familiarize one with the layout of the components. Strive to keep the block diagram in mind, the details will fall in place as experience is gained.

Checking Instrument Upon Receipt. Occasionally, upon receipt by a customer, an instrument will fail to operate properly. This may be due to rough handling or vibration that has taken place in shipment. The cause of the trouble most often will be a loose tube or perhaps some other loose plug-in component, such as a DCU or a crystal. In some cases a time base divider may require re-alignment, but rarely is more than one divider out of adjustment. Refer to the manual for proper alignment procedure, and be sure to use an auto-transformer on the 117-volt input line in order to test the alignment over any expected line swing within the specified variation of ±10 per cent. Check to see that the switch on the cooling fan is turned on. At the same time make sure the INT-EXT switch on the oscillator sub-chassis is in the INT position. If the pilot light fails to come on when the POWER switch is thrown, there is probably a loose or broken line fuse. These fuses are located on the rear of the chassis.

Routine Care of Instrument. As time goes on, dust and grit may accumulate inside the chassis. This should be removed with an air hose and brush to prevent deterioration of components. Remove the tubes and clean the tops of the sockets with a rag. Make sure that the cooling fan rotates at normal speed.

HOW TO TRACE A FAULT TO A MAJOR COMPONENT

Examining Operating Characteristics. Refer to the schematic diagram of the gate and control circuitry. You will notice that the complete instrument, excluding the power supply, is shown on this page either in detailed schematic form or block diagram. It is your best overall look at the instrument and with reference to this diagram you can trace the signal and pulse paths through the function switch to their destinations. Understanding this diagram is the key to the isolation of troubles in the entire instrument. Notice that the input trigger channels, the oscillator and the frequency dividing chain all feed pulses to the FUNCTION switch, but that at some positions of the FUNCTION switch not all the pulse sources are coupled to succeeding circuits. Since some major components are not used while performing certain operations, a fault may often be localized by observing which functions fail. For example, no pulses from an input trigger channel are used during the TEST operation; therefore, one may reasonably suppose an input channel is at fault if the instrument operates all right at TEST, but does not operate with an input signal. To take another example, the frequency dividing chain has no part in the COUNT operation, so if the instrument performs this function successfully when other functions fail, one may suspect the dividing chain.

Signal Substitution Using Another 7000 Series Instrument. Another 7000 Series instrument in good operating condition is a great help in localizing trouble. Make up a couple of patchcords, three or four feet in length, and having the BNC type connectors on both ends. These will serve to conduct pulses from one unit to another. On the rear lip of the chassis you will find two connectors, one labeled TIME and the other FREQ. The clock pulses from the frequency dividers are available at the TIME jack, and the oscillator frequency is present at the FREQ jack.

If you suspect incorrectly timed clock pulses in a faulty instrument, their accuracy can be checked by introducing the clock pulses from a good instrument into the B channel of the defective instrument and obtaining a readout in the PER function. Make this test with several combinations of the TIME-SECONDS switch on both instruments. Have both SLOPE switches at the same polarity. Be sure that the oscillator of the good instrument has been carefully set to the correct frequency before attempting this type of test.

Another test is to patch the oscillator output from the good unit into the FREQ jack of the faulty one and throw the INT-EXT switch, located on the oscillator sub-chassis, to the EXT position, thus bypassing the oscillator of the defective instrument. Don't overlook the possibility of counting the clock pulses from a good instrument as a check on the accuracy of the E/UT function of a suspected instrument.

Observing Pulses at the FUNCTION Switch. The FUNCTION switch consists of four wafers. With one exception, there are contacts on both sides of each wafer. The contacts on each side make up one section, and each section is identified on the schematic diagram of the gate and control circuitry by a letter from A to G. Section A is the rear side of the wafer nearest the front panel (the forward side of this wafer is not used). The forward side of the second wafer is section B; the rear side, section C, and so on. A scope probe may be conveniently placed on the wiper contacts of sections C, E and G in order to observe "start", "stop" and "count" pulses respectively. These pulses originate in one or another of the major components depending upon the position of the FUNCTION switch. By rotating the switch to various positions, one may observe the output of an input channel, the oscillator-shaper, and (in conjunction with the TIME switch) the output of any frequency divider.

INPUT TRIGGER CHANNELS

Referring to the schematic, notice that the internal test signal does not pass through an input trigger channel, so, given a correct reading at TEST, it is a good bet that the trouble lies here. There are only three tubes in an input channel and the entire channel is contained on one sub-chassis. Thus troubleshooting is confined to a small amplifier-shaper section of the circuitry.

No one can state as a general rule where the trouble will be found in an input channel. The most likely cause of trouble is a defective tube and substitution should be tried. Then, of course, find out if the correct supply voltages are present. It is always wise to check supply voltages before doing any trouble-shooting, but remember if we found a correct TEST reading, we can assume that the supply

voltages are correct for most of the circuitry. Ordinary signal tracing, using the scope, may be employed on an input channel and typical voltages listed on the diagram may be verified with a vacuum-tube voltmeter. Don't overlook comparison of waveforms with those of a similar instrument that you may have in your possession, but remember that the attenuator and trigger voltage controls should be in identical positions on both instruments. Turn off the power to the faulty instrument and take resistance measurements, perhaps the defective component will show up by this method. At any rate one of the above methods should yield results and the time required for the repair will depend on the skill of the technician and his familiarity with the instrument.

OSCILLATOR-SHAPER

The oscillator is the heartbeat of a 7000 series instrument; without it, operation ceases, except for the A/B function which is independent of the oscillator. Therefore, one of the first things to investigate, after noting a complete failure to count in the TEST position, is the oscillator.

Look at the oscillator sub-chassis to be sure that the INT-EXT switch has not been accidentally thrown to the EXT position. Put the scope probe on pin 2 of V402, (or on the FREQ jack on the rear of the instrument): the oscillator output waveform should appear, a distorted sine wave in the range of 10 to 16 volts peak-to-peak. A value of about 12 volts is normal, but the instruments will operate correctly over at least the range noted above. If this waveform is not present, adjust C410, marked "XTAL ADJ" on the chassis. (Upon completion of the repair, don't forget to reset this control so that the oscillator frequency will be precise.) If a spare crystal is available it should be tried as a substitute but with a new crystal the value of C404 may need to be changed as suggested in the manual. Remaining components and wiring can be checked with an ohmmeter.

Located on the same sub-chassis as the oscillator is the shaper circuitry. This section amplifies and shapes the signal generated by the oscillator. If the proper oscillator signal was found to be present when checked with a scope at pin 2 of V402, the oscillator is not at fault and trouble may be found in the shaper. Place the scope probe on pin 1 of V402; a waveform should appear, with a peak-to-peak value of from 12 to 20 volts. The appearance of this waveform will differ in the 100kc and 1mc models, and will also depend on the setting of the SHAPER LEVEL control, R414, located in the pin 2 grid circuit of V402.

After repairing the trouble be sure that the SHAPER LEVEL control is reset properly as described in the manual, but, before doing this, rotate it back and forth, noting whether operation is restored with the FUNCTION switch at TEST. You will find that there is a range of settings within which the instrument will perform correctly, but a setting well to the side of this range may cause entire lack of amplification through the shaper tube. Other points to check are the B supply voltage, the tube and the small choke coil, L402. Other components may be checked in the usual manner. Most component values in the oscillator-shaper circuit are not critical.

TIME BASE DIVIDERS

Be sure to make use of the circuit description and waveforms published in the instruction manual when shooting troubles in the dividers. The amplitudes listed on the waveform photographs are approximate: there is appreciable variation among instruments. It is advisable to become familiar with the adjustment of the dividers before trouble occurs. Practice on an instrument that is known to be in good operation. Put the unit in the TEST function and take note of the readings obtained as the first divider is misadjusted, then the second, the third and so on. An actual trouble will probably occur in a single divider only, so the complication of more than one divider being out of adjustment is rare.

Make certain that the supply voltage of +120 volts is present and well-regulated. Make sure that the input pulses from the oscillator-shaper are entering the divider chain. Use the TIME-SECONDS switch and the readout on the DCU's to pin down the defective stage. Check division ratios with a scope at the points suggested in the manual. A slight adjustment of one divider may bring a unit back to normal, or perhaps the replacement of one tube may have the same result. Do not overlook the possibility that the TIME TRIGGER LEVEL control (R606) is set incorrectly. Aged tubes should be used as replacements in the divider chain in order that the original adjustment will hold for several months or more. Replacements for the 6U8 (V601) should be Sylvania brand for best performance. The adjustment procedure for the dividers and the TIME TRIGGER LEVEL control is well covered in the instruction manual; no further mention will be made here.

The voltages shown in the table on page 6 will be of real help in servicing the dividers. Notice that all the dividers, except V608 (contained in Models 7160 and 7360 only), are identical, so voltages and resistances in one stage may be compared with those in another. A convenient point to monitor the clock pulses is at the TIME jack, located on the rear lip of the chassis.

GATE AND CONTROL CIRCUITRY

Learning How the Circuits Operate. No one can hope to be successful in troubleshooting the control circuitry unless he understands the operating cycle. First, study the circuit description and the cyclic timing diagrams reproduced in the manual. Second, if possible, study the circuitry in a well-functioning instrument while it resets in each of its three stable states: "ready time", "counting time" and "display time". (The fourth state of the operating cycle, the "inhibit start time", is a transient condition lasting only a few milliseconds.) Use the following procedure:

(a) Rotate the DISPLAY control clockwise until a switch clicks. This prevents the instrument from resetting automatically.

(b) Place the FUNCTION switch at some position at which an input trigger channel supplies "start" and "stop" pulses, but do not couple an input signal to the channel.

(c) Press the RESET button. After a brief "inhibit start" period, the circuitry should switch to the "ready time" state. This state may then be studied deliberately with a VTVM.

(d) Introduce a "start" pulse by rotating the trigger voltage control on the input channel back and forth. The circuitry should then assume the "counting time" state.

(e) Introduce a "stop" pulse by moving the trigger voltage control back and forth again. This should place the circuitry in the "display time" state.

Troubleshooting. The control circuitry is the most difficult part of the instrument to service; therefore, be sure it is receiving adequate input signals ("start", "stop" and "count" pulses) before beginning to search for trouble. The following troubleshooting procedure is recommended.

Step 1. Observe signal at control grid of gate tube (V204, pin 1). Pulses to be counted should appear here. If not the DCU's will not count even though the control circuitry is functioning perfectly.

Step 2. Observe the d-c voltage change at the gating grid (V204, pin 7) while the control circuitry is receiving start and stop pulses separated by one second or more and is adjusted to reset automatically. If the d-c voltage switches back and forth from -15v or more negative to ground level or more positive, the control circuitry is operating all right. In this case inspect the gate tube and associated components for defects. If a sufficient voltage change fails to appear, proceed to step 3.

Step 3. Attempt to place the control circuitry in the "ready time" state by following steps (a) thru (c) above. If the DCU's do not reset, search for trouble in the reset circuitry (V205 & V206). In particular, inspect diodes CR205 and CR209. If the reset line has been accidentally shorted to ground these diodes may burn out. If the DCU's reset correctly proceed to step 4.

Step 4. See whether the reset pulse has switched the control circuit binaries to the "ready time" state. The d-c voltage at pin 1 of both V202 and V203 should be about -47v. If voltages approximating these fail to appear, check the tubes and associated circuitry. If adequate voltages appear, proceed to step 5.

Step 5. Try to switch the binaries to the "counting time" state by introducing a start pulse as described under (d) above. Both binaries should change state, causing the d-c voltage at pin 1 of both V202 and V203 to change to approximately -10v. If either binary fails to "flip", the tube or associated components may be at fault. The cause may also be one of the injection diodes (CR211 or CR212). Check voltages and components using ordinary techniques, but do not attempt to measure grid voltages on either binary because touching a grid pin with a probe may in itself "flip" the binary. If both binaries have changed state proceed to step 6.

Step 6. Attempt to place the circuitry in the "display time" state by injecting a stop pulse as described in (e) above. The control binary should change state, causing the voltage at pin 1 of V203 to return to approximately -47v. The automatic reset action begins when a stop pulse occurs. If you adjust the counter for an automatic display period of 4 or 5 seconds, you may check this action by observing the gradually rising voltage at pin 7 of V206. The voltage there should change from about -1v to +20v.

TYPICAL VOLTAGES AND RESISTANCES

The following voltages and resistances appear in a Model 7360. The table is valid for all other 7000 Series instruments (Models 7050, 7060, 7150, 7160, 7250, 7260, 7350 and 7360) except that some of the tubes or other plug-in components listed will not be installed in the instrument. The resulting lower load on the power supply may cause unregulated voltages to rise 5%. Ordinarily, readings may vary ±10% from the typical value without causing trouble. Special conditions of measurement are indicated by letter superscripts ("a", "b", "c", etc.) which refer to notes at the end of the table. Otherwise conditions are as follows:

1. Voltages measured with a VTVM having an input impedance of 11 megohms.
2. Line voltage 117 volts.
3. FUNCTION switch at OFF.
4. TIME switch at 10^{-6}.
5. ATTENUATION controls at "DC1".
6. DISPLAY control turned clockwise until switch clicks.
7. Instrument in "ready time" state; that is, after reset but before a start pulse occurs.
8. No input signals coupled to the instrument.

D-C Supplies	DC Volts with respect to ground	Resistance to ground in Ohms	Plug-in DCU	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
Unreg. B+	+200	7.4K				
Reg. B+	+120	4.5K	A202	Same as A205		
Unreg. B-	-116	7.8K	A203	Same as A205		
Reg. B-	-54 to -66	8.1K	A204	Same as A205		

Plug-in DCU	Pin No.			Plug-in DCU	Pin No.		
A201	1	Fil -116	7.3K	A205	1	Fil -116	7.5K
	2	-116	7.5K		2	-38	1.5M
	3	-116	8.9K		3	-116	7.5K
	4	-60	68K		4	-54	66K
	5	+210	7.5K		5	+210	7.5K
	6	N.C.			6	-51	1.42M
	7	210	30K		7	-54	63K
	8	-114	7.3K		8	-116	7.4K
	9	N.C.			9	-49	1.46M
	10	+21	∞		10	-48	1.46M
	11	Fil -116	7.6K		11	Fil -116	7.5K

Plug-in DCU	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
A206	1	Fil -116	7.5K
	2	-39	1.5M
	3	-116	7.5K
	4	-54	63K
	5	+210	7.5K
	6	-51	1.42M
	7	+89	16.8K
	8	-116	7.4K
	9	-50	1.42M
	10	-48	1.44M
	11	Fil -116	7.5K
A207	1	Fil	
	2	-20	580K
	3	0	0
	4	+89	16.8K
	5	+210	7.5K
	6	+13.5	660K
	7	+119	5.5K
	8	+0.55	300[b]
	9	-29	570K
	10	-18	650K
	11	Fil	
Tube			
V101	1	-2.1	470K
	2	0	0
	3	Fil	
	4	Fil	
	5	+90	110K
	6	+92	28K
	7	0	0
V102	1	+87	110K
	2	+210	7.5K
	3	+120	4.8K
	4	+85	110K
	5	+210	7.5K
	6	+120	4.8K
	7	Fil	
	8	Fil	

Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
V202	1	-47/-9/-3[cd]	11K
	2	-82/-92/-92	34K
	3	-80	18K
	4	Fil	
	5	Fil	
	6	-11/-48/-48	11K
	7	-91/-81/-81	42K
	8	-80	18K
	9	Fil	
V203	1	-47/-10/-47	5.8K
	2	-92/-101/-91[cd]	21K
	3	-91/-92/-91[cd]	12K
	4	Fil	
	5	Fil	
	6	-11/-54/-11[cd]	7.2K
	7	-99/-91/-99[cd]	42K
	8	-91/-92/-91[c]	12K
	9	Fil	
V204	1	-5.3/-6.4/-6.4[c]	22K
	2	0	0
	3	Fil	
	4	Fil	
	5	+120	5.8K
	6	+120/+118/+116[c]	5.9K
	7	-18/+0.3/-18[c]	200[b]
V205	1	+40/+37.5/+200[c]	82K
	2	-0.5/-0.5/-28[c]	320K
	3	0	0
	4	Fil	
	5	Fil	
	6	+210	7.5K
	7	-37.5/-37.5/+40[c]	605K
	8	-32	25K
	9	Fil	

Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
V206	1	+61	25K
	2	+32	4.4M
	3	+32	3.3K
	4	Fil	
	5	Fil	
	6	+210	61K
	7	-1/-1/+20[ce]	8.5M
	8	+32	3.3K
	9	0	
V207	1	+93	18.5K
	2	+13	530K
	3	+13	1.0K
	4	Fil	
	5	Fil	
	6	+210	32K
	7	0	24K
	8	+13	1.0K
	9	Fil	
V301	1	+79/+82[f]	14.5K
	2	+2.1/-1.7[f]	varies w/setting of trigger voltage potentiometer
	3	+5.3/+2.9[f]	28K
	4	Fil	
	5	Fil	
	6	+88/+87[f]	14.5K
	7	-99	10M
	8	+5.3/+2.9[f]	28K
	9	Fil	
V302	1	+50/+52[f]	17K
	2	-3.5/-3.9[f]	69K
	3	+1.75/+2.10[f]	18K
	4	Fil	
	5	Fil	
	6	+69/+68.5[f]	12K
	7	-2.9/-1.9[f]	69K
	8	+1.75/+210[f]	18K
	9	Fil	
V303	1	+119/+119[f]	5.1K
	2	+50/+52[f]	17K
	3	+110	5.1K
	4	Fil	
	5	Fil	
	6	+92/+91[f]	7.5K
	7	+61/+62[f]	
	8	+61/+62[f]	6.8K
	9	+59/+58[f]	10.0K
V401	1	+88	63K
	2	0	115K
	3	+116	5.1K
	4	Fil	
	5	Fil	
	6	+116	5.2K
	7	+3.1	680K
	8	0	0
	9	-3.6	2.7M
XY401 (crystal)	1	117 AC	
	2	N.C.	
	3	N.C.	
	4	N.C.	
	5	0	0
	6	117 AC	0
	7	+89	63K
	8	0	∞
V402	1	+116	5K
	2	+58	47K
	3	+116	5K
	4	Fil	
	5	Fil	
	6	+92	7.5K
	7	+62	6.8K
	8	+62	6.8K
	9	+58	9.5K

Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms	Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
V601	1	+120	4.2K	V605	1	+65	26K
	2	+58	45K		2	+22	118K
	3	+115	5.0K		3	+24	8.2K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+83	7.2K		6	+105	25K
	7	+59	7.1K		7	-1.7	4.0M
	8	+59	7.1K		8	+24	8.2K
	9	+50	8.8K		9	Fil	
V602	1	+67	25K	V606	1	+66 $\pm 10^{g}$	26K
	2	+22.5	120K		2	+22 $\pm 2^{g}$	118K
	3	+24	8.2K		3	+25 $\pm 1^{g}$	8.2K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+104	25K		6	+105 $\pm 11^{g}$	26K
	7	+5.2	4.1M		7	-4 $\pm 16^{g}$	4.0M
	8	+24	8.2K		8	+25 $\pm 1^{g}$	8.2K
	9	Fil			9	Fil	
V603	1	+106	26K	V607	1	+120	4.6K
	2	+2.0	4.1M		2	+54	58K
	3	+24	8.2K		3	+54	15K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+105 +66	25K		6	+23.5	4.0K
	7	+22.5	120K		7	+23.5	4.0K
	8	+24	8.2K		8	+29	30K
	9	Fil			9	Fil	
V604	1	+66	26K	V608	1	+109	7.3K
	2	+21.5	120K		2	+19	11.5K
	3	+24	8.2K		3	+24	5.0K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+106	26K		6	+85	7.6K
	7	+0.8	4.1M		7	+29	30K
	8	+24	8.2K		8	+24	5.0K
	9	Fil			9	Fil	

Notes

a. This DCU is installed only on instruments which feature "X10" positions of the FUNCTION switch.

b. Resistance reading here will vary with amplitude and polarity of the voltage applied by the measuring device. This reading was obtained using an RCA type WV-98A Volt-Ohmyst on the R X 100 range, negative terminal grounded.

c. Three voltage reading taken: the first with the instrument in "ready time" state; the second, in "counting time" state, the third, in "display time" state.

d. This pin is connected to a binary grid or plate. If you touch the pin with a probe, the binary may "flip", thus producing a wrong reading. Therefore, when measuring the voltage here attach the probe first, then cause the instrument to pass through the three stable states in the operating cycle.

e. To obtain the third reading place the instrument in the "display time" state with display control in ∞ position, then rotate the DISPLAY control CCW just far enough to cause the switch to click. The voltage should begin rising from ground level, reaching about +20v in approximately ten seconds.

f. Two voltage readings taken: the first with the associated TRIGGER VOLTAGE control fully clockwise; the second, with the control fully CCW.

g. This divider stage cycles so slowly that the needle of a voltmeter will wobble visibly within the range noted.

NOTE

Modified instruments are identified by one or more letters after the model number, each letter standing for one of the modifications described. For example, the Model 7150DR is a standard 7150 that has been modified to incorporate an oven-controlled crystal instead of an unheated crystal (Modification D) and is fitted for rack mounting (Modification R).

Some modifications in this section may not appear in alphabetical order.

Not all the modifications described are applicable to every instrument. For information on suitable modifications, get in touch with the factory or with any of the Beckman representatives listed at the back of the manual.

MODIFICATION B

Modification B extends the count capacity by a factor of 10 or divides the frequency of the start and stop pulses by 10.

Models 7151, 7351, 8151, and 8351

A Model 775Z (Model 777Z for 8151 and 8351), A705, is placed between the Divider Input Gate, V701, and DCU A704. When switch S206 is in the "N X 10" position, A705 divides the digital divider drive pulses by 10, raising the maximum input frequency from 10 kc to 100 kc. In the "N X 1" position, the instrument works as if unmodified. The circuit changes are shown in Figure B.

Other Models

The schematic diagrams of the other instruments for which modification B is available show the modified circuitry.

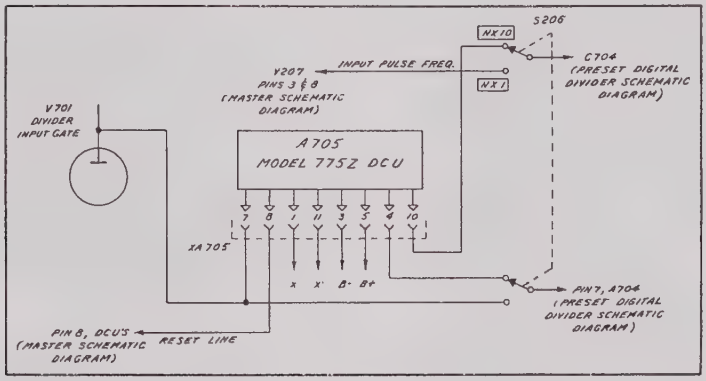


FIG. B. Circuit changes for modification B in Models 7151, 7351, 8151, and 8351.

MODIFICATION C

An instrument with modification C has a mechanical register that extends the count capacity by three extra digits. The register coil is the plate load of a one-shot multivibrator, V21 driven by the output signal of DCU A202; thus, the register records one count for every output pulse of the DCU.

The register is reset manually by a small lever on the front panel just below the register dials and is not affected by the electronic signal that resets the DCU's.

In C-modified instruments with "X 10" modes of operation, the count-indicating panel of the DCU Divider, A201, is not exposed to view, and the digit normally displayed by A201 appears as the right-hand digit of the register.

When A202 resets, it may give an output pulse. To stop this from registering, the reset line is connected to the control grid, pin 2, of V21 so that the inverted reset pulse appearing at the plate, pin 1, suppresses the false count.

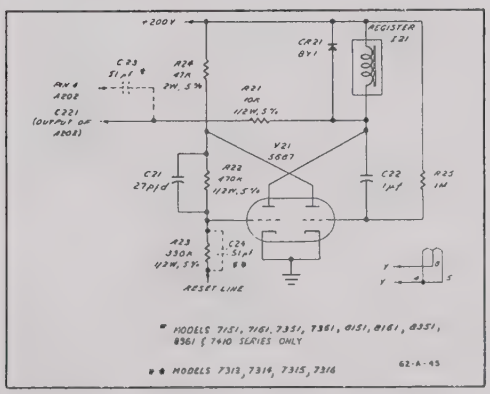


FIG. C. Circuit of modification C.

MODIFICATION D

The frequency stability of the clock pulse generator in instruments using an unheated crystal is 1 part in 10^5 per day. Modification D substitutes a temperature-controlled crystal for the unheated type and improves the oscillator stability to 1 part in 10^6 per day.

Power for the heating element in the crystal oven is taken from one of the filament circuits in the instrument (the circuit that has one side grounded). The circuitry is shown on the crystal oscillator schematic diagrams of the instruments concerned.

MODIFICATION H

Instruments with this modification have a power transformer with a 222-volt primary instead of the standard 117-volt, the primary being two windings in series, a 117-volt and a 105-volt. The line fuses, F101 and F102, have one-half the current rating of those in the standard instruments. Figure H-1 shows the modified circuitry. Note that in instruments with a 1 Mc heated crystal in the oscillator, the crystal oven no longer begins heating as soon as the line cord is plugged into a power receptacle, but heats only when the POWER switch is on.

If operation on 210 volts or 231 volts is desired, take the wire off terminal 2 of the transformer and connect this wire to terminal 14 or 11 respectively.

To convert to 117-volt operation, rewire the transformer connections as shown in Figure H-2 and replace F101 and F102 with fuses of twice the current rating.

If an instrument with the H modification also has an N modification, refer to the N modification section for further details on power transformer and wiring changes.

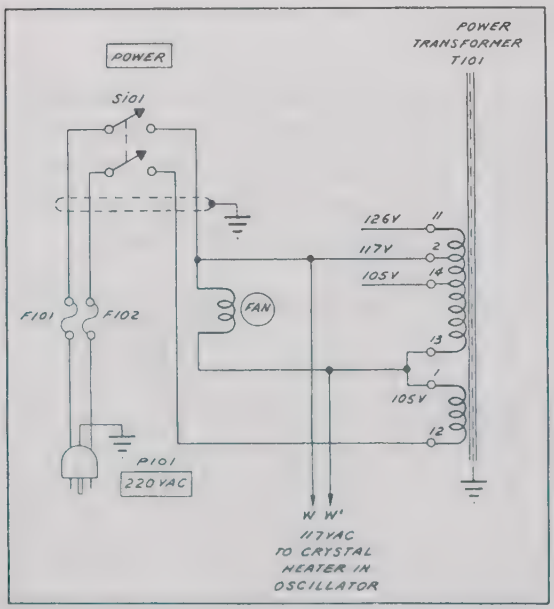


FIG. H-1. Circuit changes in power supply for modification H.

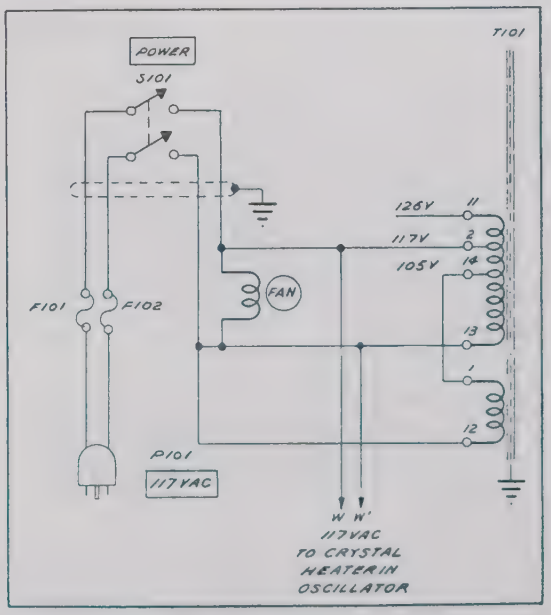


FIG. H-2. Rewiring modification H to operate on 117 volts ac.

MODIFICATION J

Modification J raises the maximum counting rate of 100 kc instruments to 220 kc, and 1 Mc instruments to 2.1 Mc.

100 kc Instruments

DCU A206 is replaced by a 220 kc DCU, Model 713AH, and the circuitry of the instrument is modified to suit the new unit as shown in Figure J-1.

1 Mc Instruments

a) DCU A207 is replaced by a 711AH, and A206 by a 713AH. Each of these DCU's has about double the counting speed of the unit it replaces. The plate load of the Gate Control tube in the instrument is changed and the circuitry immediately associated with the new DCU's is modified as shown in Figure J-2.

b) In addition, any input channels required to operate between 1 Mc and 2 Mc in count modes are supplanted by faster channels with a cathode follower between the comparator amplifier and the voltage discriminator. These 2 Mc input channels are shown in Figure J-3 (A or B channels, where appropriate) and Figure J-4 (C channel only).

c) In the Models 7360 and 8360 only, a 33$\mu\mu$f capacitor, C247, is added in parallel with resistor R256 (see Master Schematic Diagram).

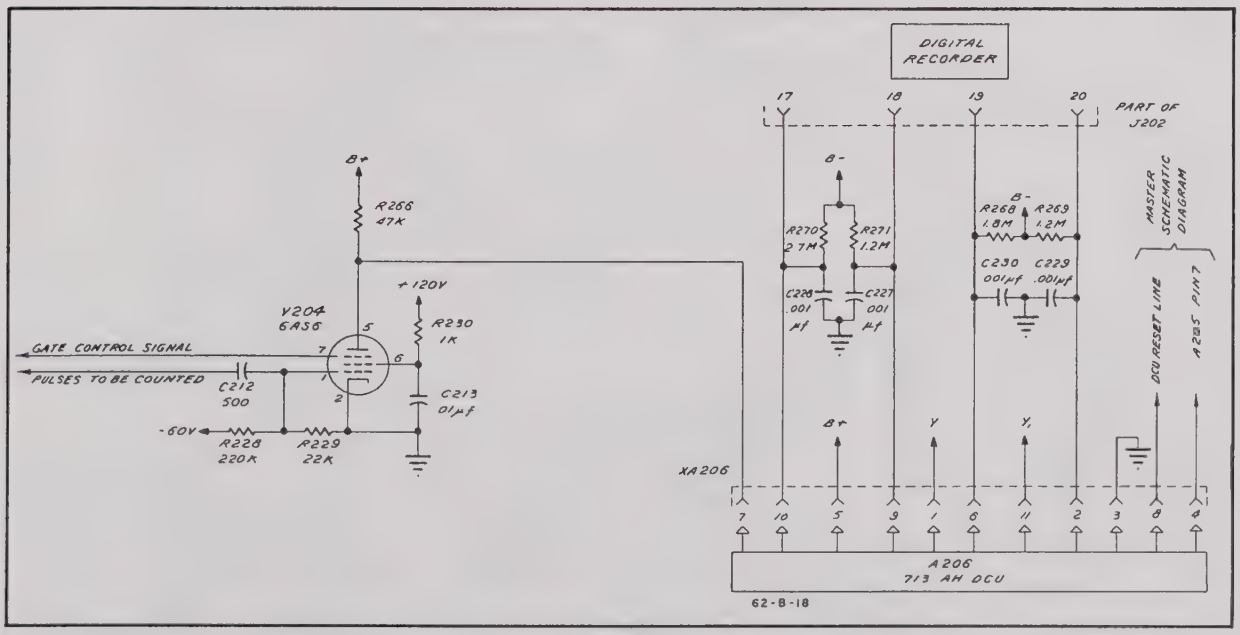


FIG. J-1. 100 kc instrument modified for 200 kc operation.

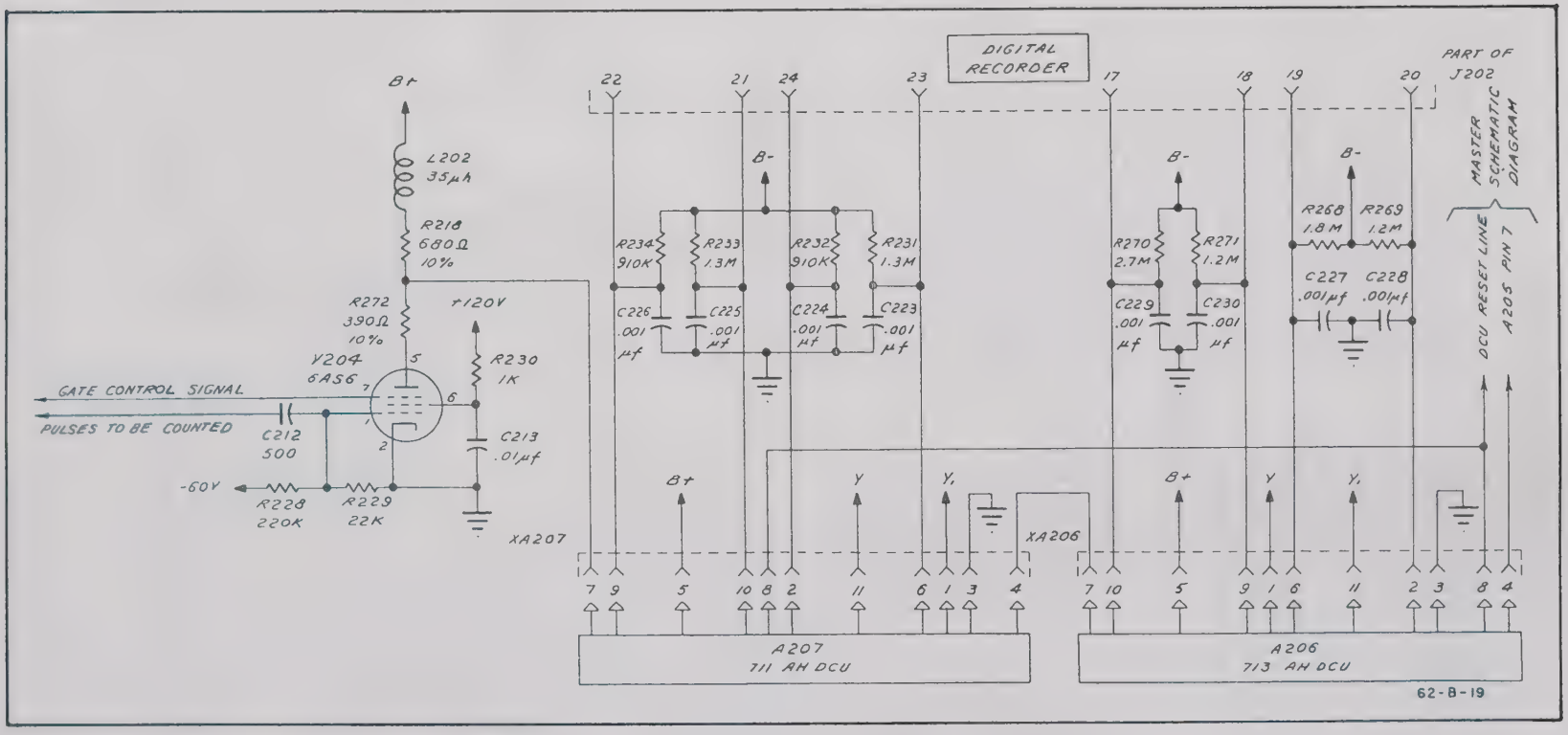


FIG. J-2. 1 Mc instrument modified for 2 Mc operation.

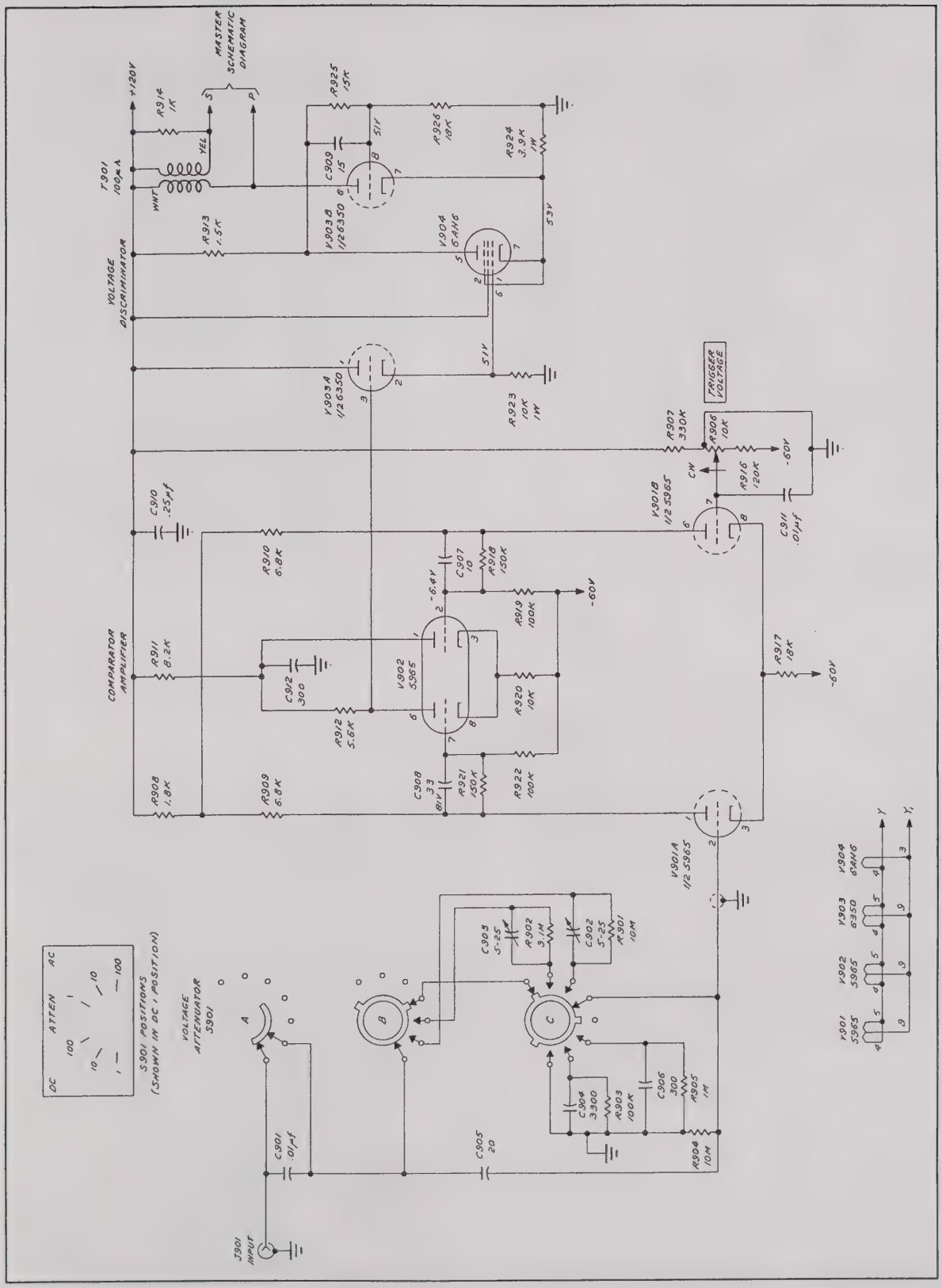


FIG. J-3. A or B input channel in 2 Mc J modification.

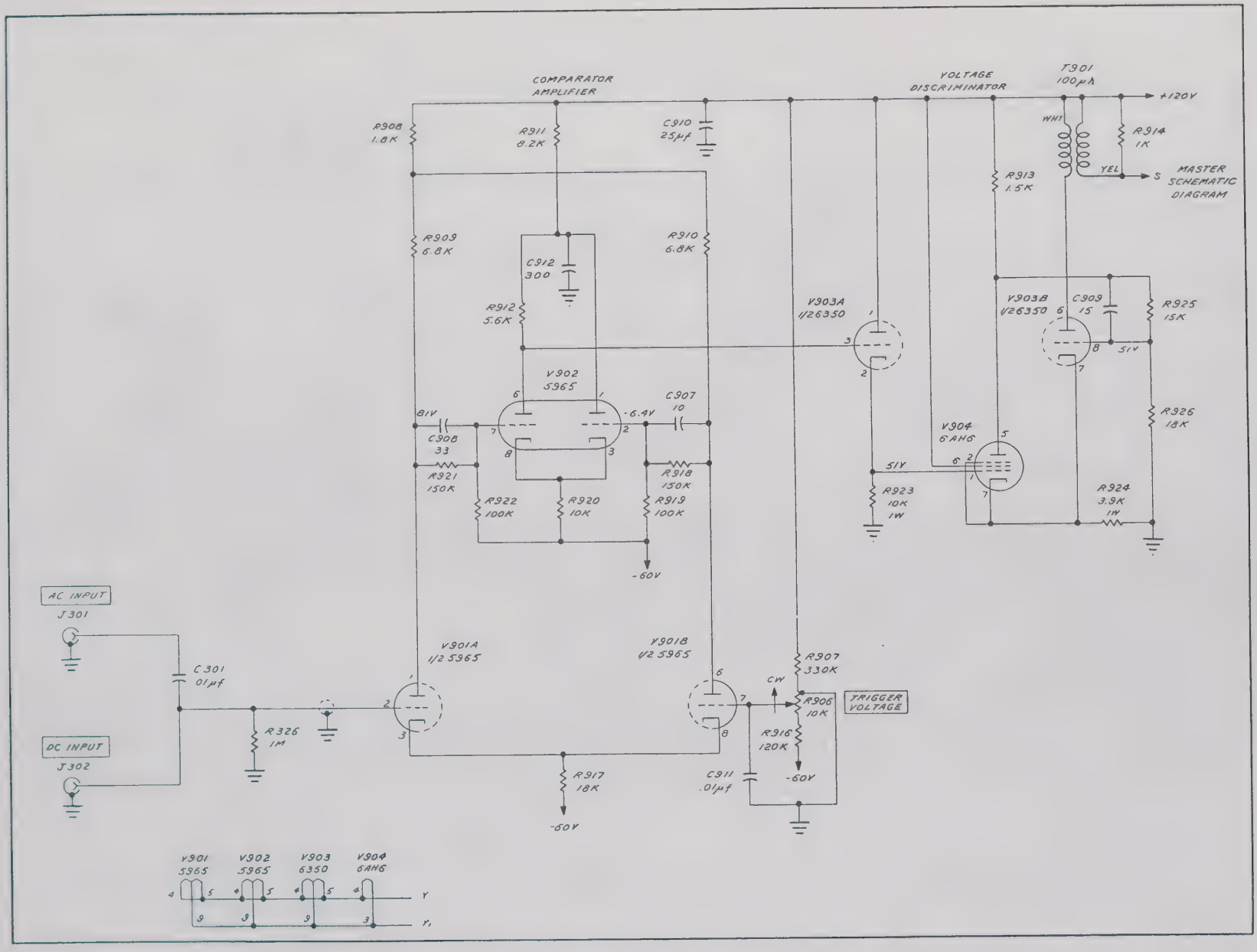


FIG. J-4. C input channel in 2 Mc J modification.

MODIFICATION K

To increase the input sensitivity of a counter from 100 mv rms to 5 mv rms, a step-up transformer is inserted between the attenuator and the first grid of any input channel used in count modes. The transformer is put in or out of circuit by a front panel switch (S350) marked HIGH (transformer in) and NORM (transformer out and attenuator connected straight through to the first grid). It should be switched in only if the input signal is below the sensitivity of the counter.

With the transformer connected, the ATTENUATION control should be at DC-1. Under these conditions the input impedance will vary with frequency, rising from at least 300 ohms at 5 cps to about 25K ohms at 10 kc. Sensitivity is at least 5 mv over this range.

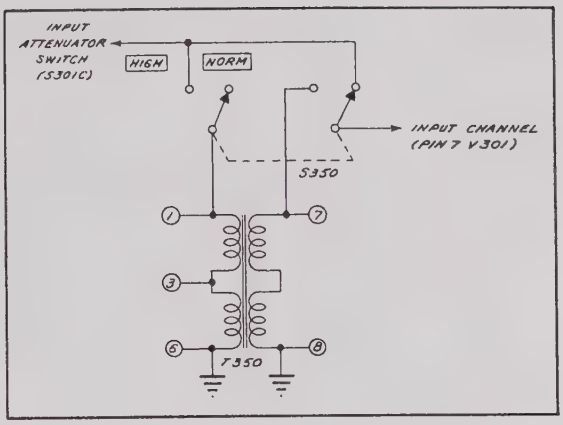


FIG. K. Circuit diagram for modification K.

MODIFICATION L

Applicable to Preset EPUT® Meters or Preset Universal EPUT® and Timers, this modification permits remote control of the digital divider setting, as well as normal control from the front panel.

The sockets of the digital divider DCU's are wired to a female connector (J801) on the rear chassis lip. One matching plug, on a flexible lead coming out of the rear lip, is wired to the internal preset switches; another is provided for wiring to remote preset switches. Front panel control or remote control is obtained by inserting the appropriate plug into J801.

Figure L shows the internal connections to J801 and gives the recommended wiring of a manually-operated external preset switch. In this application the voltages at pins 21, 22, and 23 of J801 are not used.

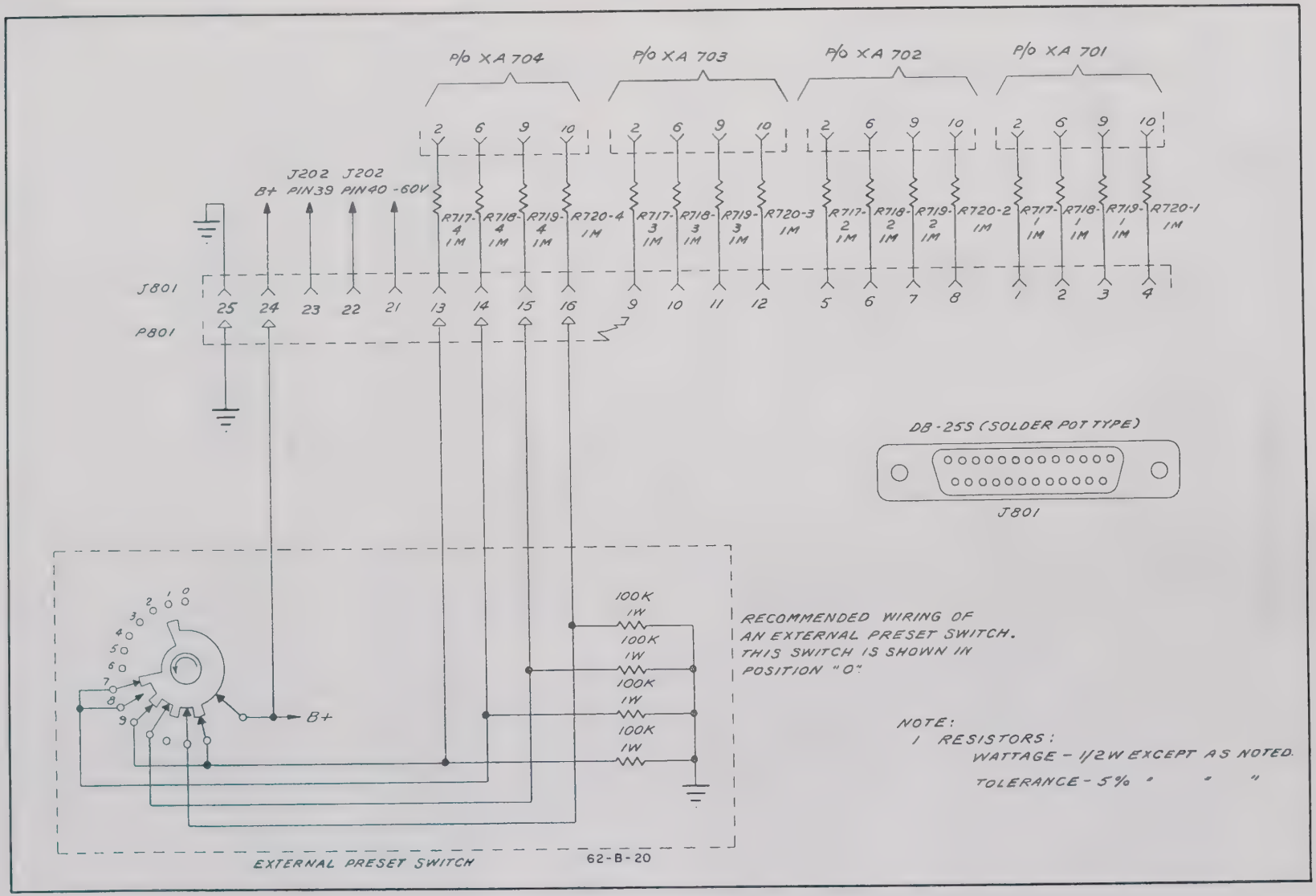


FIG. L. Wiring diagram for modification L.

MODIFICATION N

1. GENERAL DESCRIPTION

The N modification, shown in block diagram form in Figure N-1, provides an oscillator stability of 5 parts in 10^8 per week in contrast to the 3 parts in 10^7 per week of the unmodified instruments.

In place of the 1 Mc crystal oven unit that plugs into the oscillator section, instruments with this modification have a double oven mounted on the oscillator chassis. The outer oven is heated by a 117 volt element, thermostatically controlled to stay within 2° C of a nominal 70° C. Inside this oven is a second oven whose temperature is kept within approximately 0.005° C of a nominal 75° C by proportional control. The inner oven contains a temperature-stable crystal that provides the 1 Mc standard for the time base generator in the instrument. As shown in Figure N-3, the circuit of the crystal oscillator (V401) is changed and an amplifier stage (V402) is inserted between the oscillator and the shaper.

In addition, the shaper (now V601 instead of V402) is moved to the frequency divider chassis.

The heating element for the inner oven is a resistance bridge energized by the output of an amplifier (V450 and V451) located on the power supply chassis (see Figure N-3). Two opposite arms of the bridge are made of wire whose resistance changes in proportion to temperature; the other two arms are relatively insensitive to temperature changes. Amplifier and bridge form a closed-loop oscillatory circuit, the error signal from the unbalanced bridge being fed back to the amplifier input in proportion to the temperature difference between the actual and the design temperature of the oven. Since there is a continuous loss of heat from the inner to the outer oven, temperature control of the inner oven is uninterrupted. Thus, the temperature variations normally resulting from the cyclic character of thermostatic control are avoided.

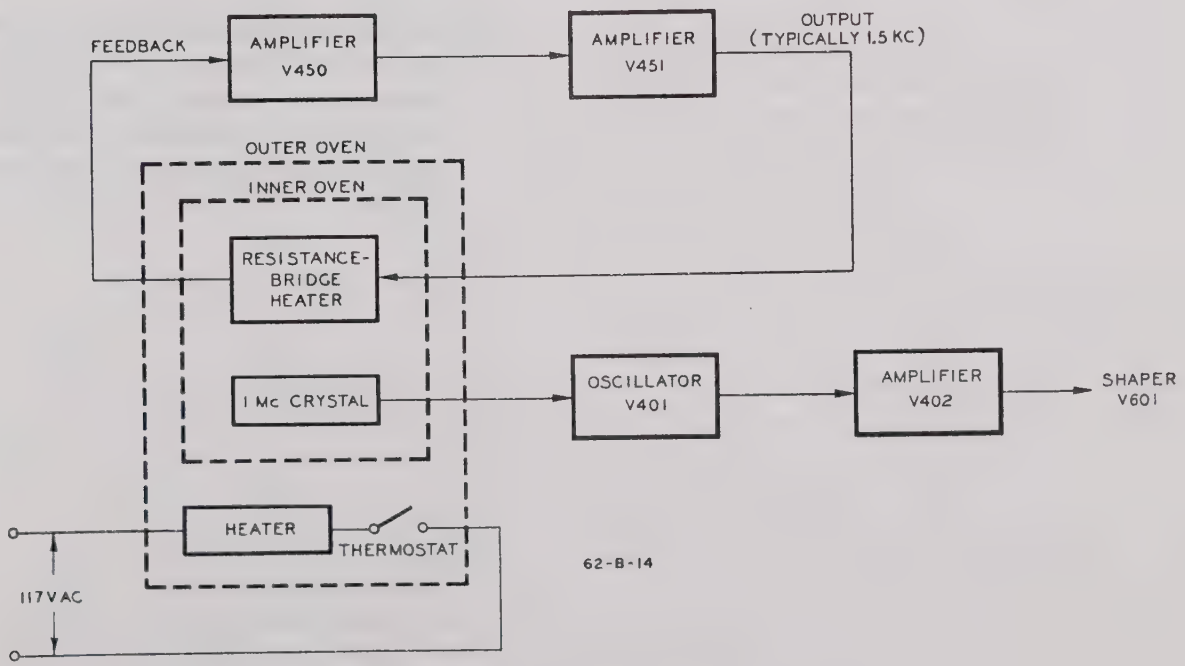


FIG. N-1. Block diagram of modification N.

1.2 OSCILLATOR ADJUSTMENTS

Oscillator adjustments are seldom required for N modifications, except when tubes or components are replaced. An adjustment procedure is given in this N modification section.

There are two adjustments in the N modification: frequency and amplitude. Frequency adjustments are made by varying C405; amplitude adjustments by tuning L401. Adjust L401 first since it has a slight effect on the oscillator frequency.

If the oscillator does not work properly, check supply voltages, tubes and components with the aid of schematic diagram, Figure N-3. When the oscillator is working, but slightly out of adjustment – either from normal use or servicing – use this procedure:

a) Adjustment of L401

1) Remove the bottom cover from the N modification assembly as shown in Figure N-2 and locate the L401 adjustment.

2) Use a VTVM to measure from the junction of R410 and R411 (see Figure N-2) to ground. Use minus polarity.

3) Tune L401 for maximum voltage. The voltage range should vary from -4 to -12 volts depending on the resonant impedance of the crystal, and characteristics of tube V401.

> NOTE
>
> Since tuning is broad, the center of adjustment can be found by rotating the tuning slug midway between the positions that cause a noticeable decrease in voltage. Inductor L401 should not be used as a frequency setting adjustment.

b) Adjustment of C405

The oscillator frequency is set at the factory. The stability is 5 parts in 10^8 per week, therefore, do not adjust unless a frequency standard at least that accurate is available. If a precise 1 Mc standard is available, follow these steps:

1) Use Figure N-2 as a guide to locate trimmer adjustment C405.

2) Connect the output from FREQ Jack J401 to the vertical input of an oscilloscope. Then, couple a 1 Mc standard to the horizontal input and adjust C405 for a Lissajous pattern indicating equal frequency.

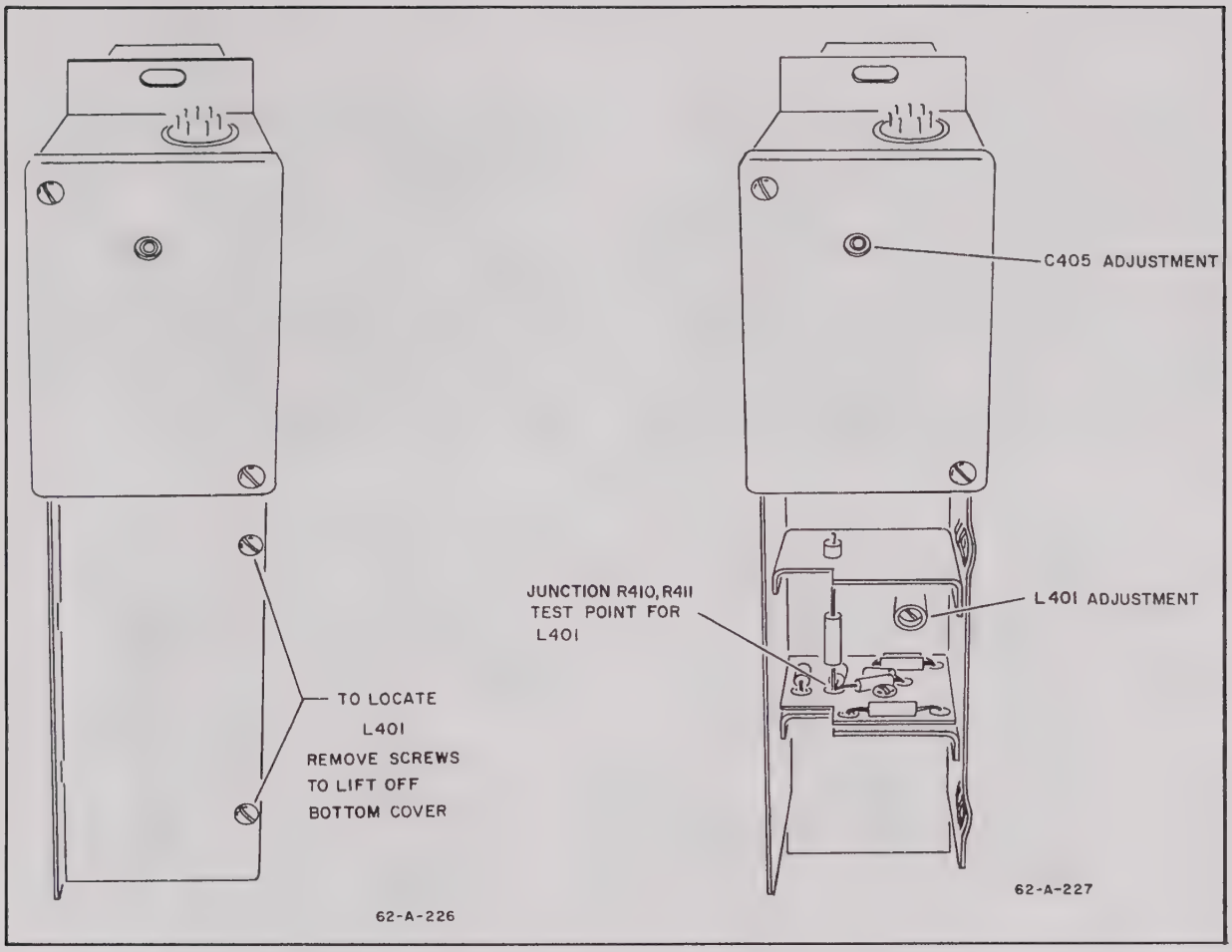


FIG. N-2. Illustrates location of N modification adjustments. Underchassis view.

Instruments having both the H and N modifications require a different power transformer for the N modification. A power transformer is used with a 222-volt primary instead of the standard 117-volt, the primary being two windings in series, a 117-volt and a 105-volt. The line fuses, F450 and F451, have one-half the current rating of those in the standard N modification. If operation on 210 volts or 231 volts is desired, take the wire off terminal 3 of the transformer and connect this wire to terminal 2 or 4 respectively. Figure HN-1 shows the modified circuitry.

To convert to 117-volt operation, rewire the transformer connections as shown in Figure HN-2 and replace F450 and F451 with fuses of twice the current rating. The correct current rating is listed on the power supply schematic diagrams of the instruments.

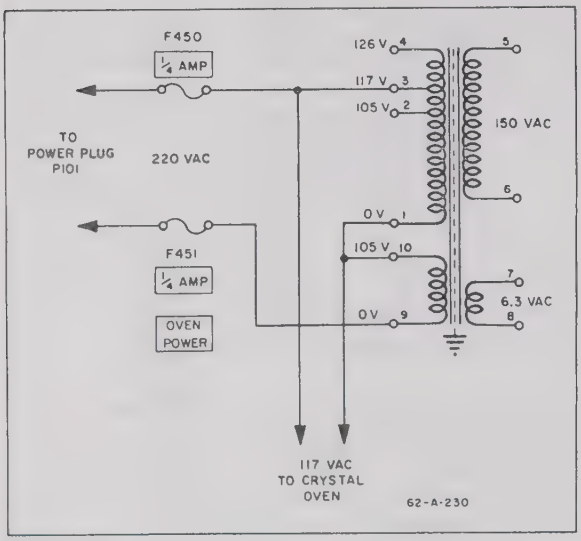


FIG. HN-1. Circuit changes in power supply for 220 volt operation.

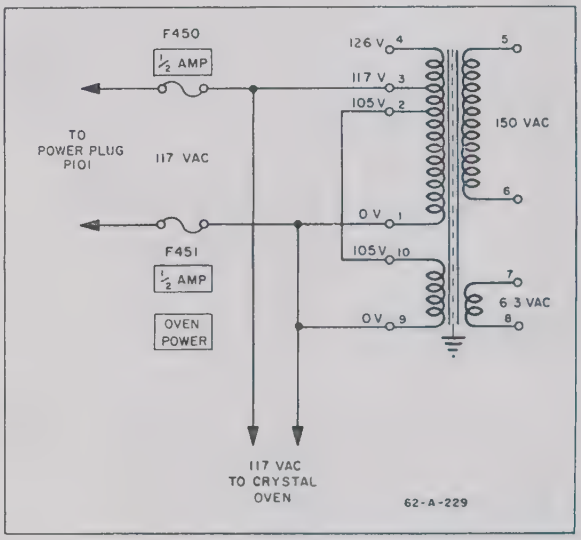
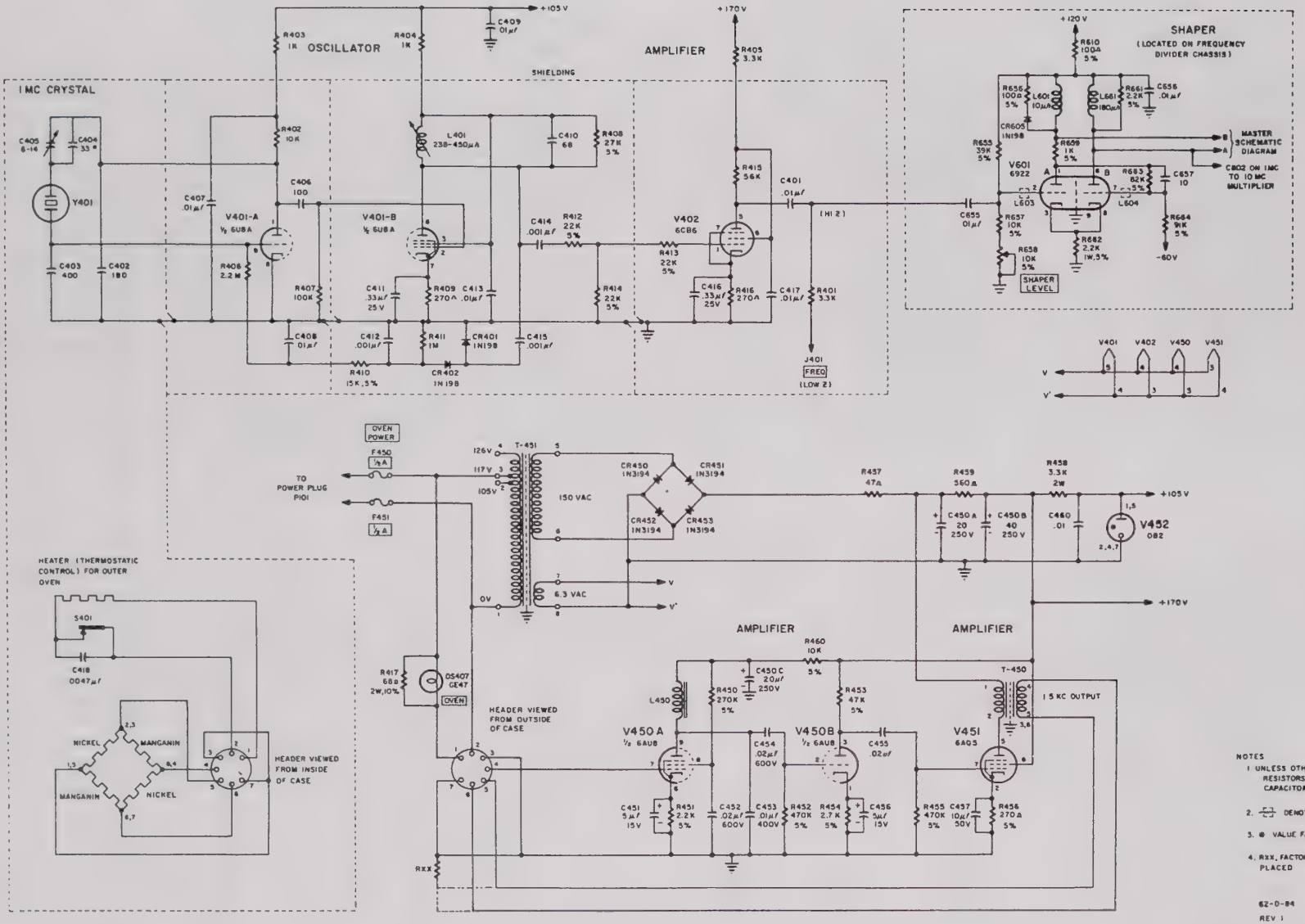


FIG. HN-2. Rewiring power supply for 117 volt operation.



NOTES

1. UNLESS OTHERWISE NOTED: RESISTORS ARE IN OHMS, ½ W, 10%; CAPACITORS ARE IN PICOFARADS
2. DENOTES FERRITE BEAD
3. @ VALUE FACTORY SELECTED
4. RXX, FACTORY SELECTED AND PLACED

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FIG. N-3. Oscillator and amplifier in modification N.

MODIFICATION R

Instruments with this modification are intended for mounting in a standard relay rack and are supplied without a cabinet but with a top dust cover. Mounting dimensions are given in Figure R.

The air intake ports in the sides of the chassis and the exhaust opening at the back should be kept free from obstruction so that the forced-draft cooling system can work efficiently. For the same reason, the dust cover must be kept in place when the instrument is in operation, as overheating can cause serious damage to components.

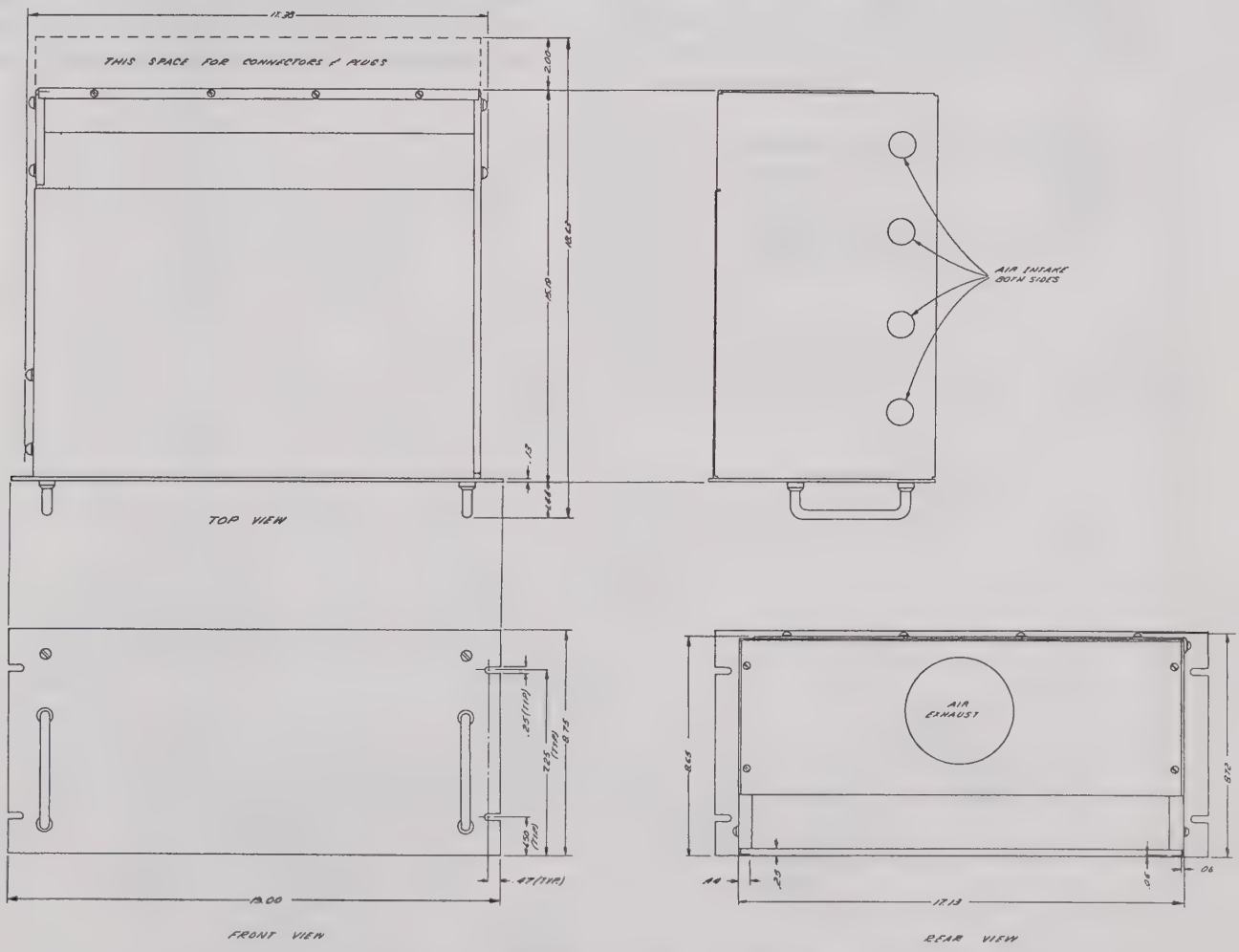


FIG. R. Rack mounting dimensions for 7000 and 8000 model series instruments.

MODIFICATION T

In contrast to the standard Beckman/Berkeley 1-2-2-4 readout code, instruments with the T modification furnish a 1-2-4-8 readout. The modified code is supplied by special DCU's substituted for the standard units. These DCU's are designated by the letter "R" following the model number.

The only modification to the wiring of the instrument is that pin 35 of the DIGITAL RECORDER connector, J202, is grounded.

MODIFICATION U

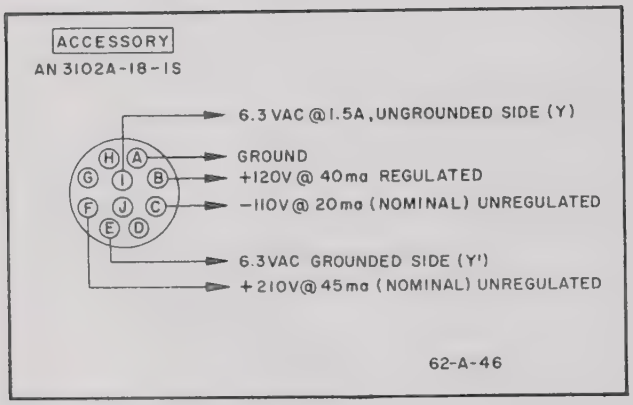


FIG. U. Connections to accessory socket in modification U.

Modification U supplies power for auxiliary equipment through an ACCESSORY socket on the rear chassis lip of the instrument.

MODIFICATION W

This modification adds a circuit that provides strobe pulses of variable width for external use (see Figure W).

The circuit consists of two identical one-shots (V901 and V902) driven by the "start" and "stop" pulses coming from the FUNCTION switch. One-shot V901 is triggered by "start" pulses, and V902 by "stop" pulses. When one of these negative pulses appears at the input grid (pin 7), the one-shot flips to the quasi-stable state and then back to its stable state. In so doing, it generates a negative output pulse of about 25 volts at one of the plates (pin 1). The duration of the quasi-stable state, and hence the width of the output pulse, depends on the capacitance put into the circuit by the STROBE PULSE WIDTH switch (S901).

The negative output pulses from the one-shots appear at the STROBES jacks (START, J901, and STOP, J902) on the rear panel of the instrument. Capacitors C201 and C206 are replaced by C919 and C920 respectively. The pulses can be applied to the Z axis of an oscilloscope to intensify the input waveform at the points where the input channel of a counter is being triggered.

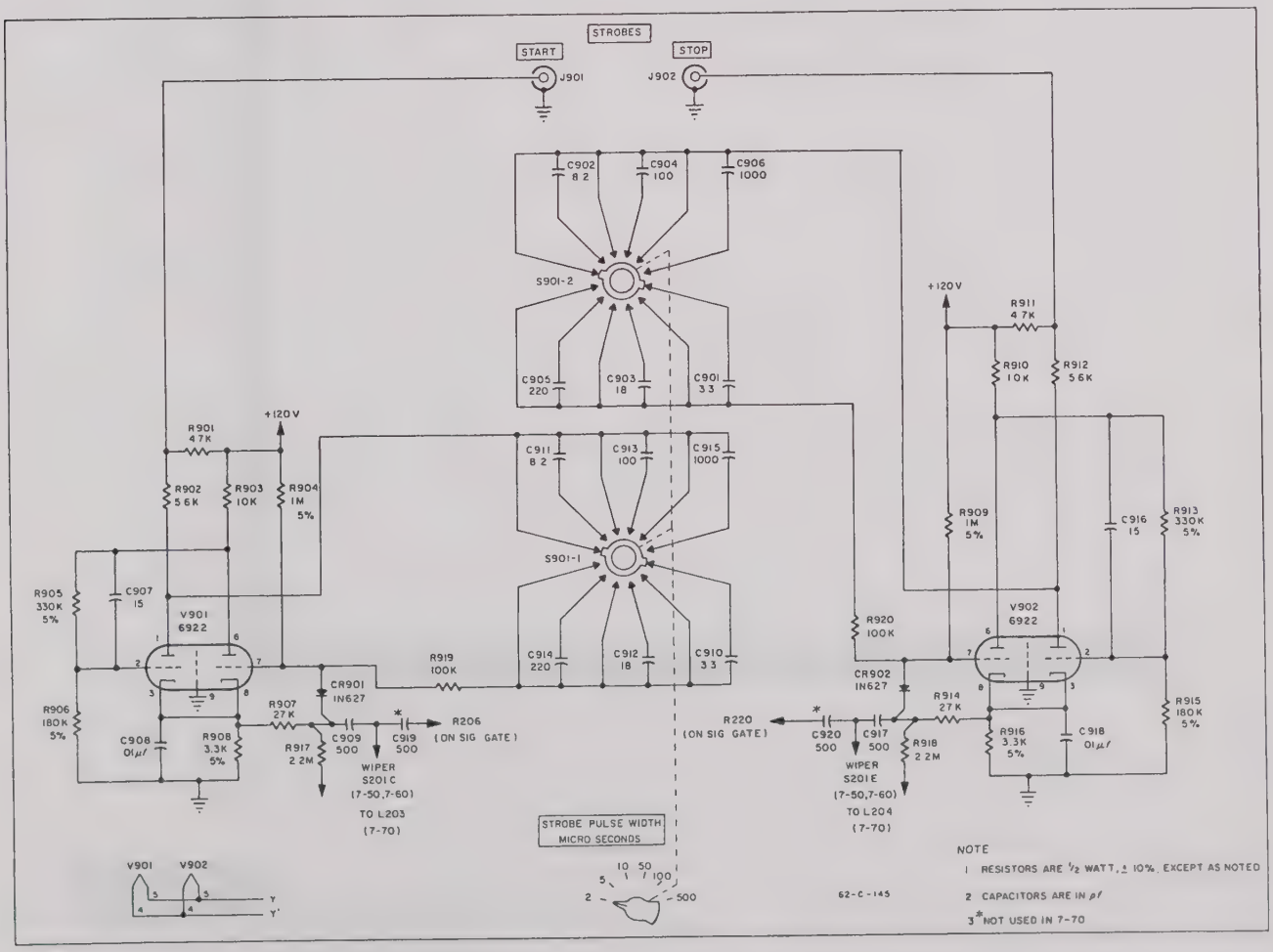
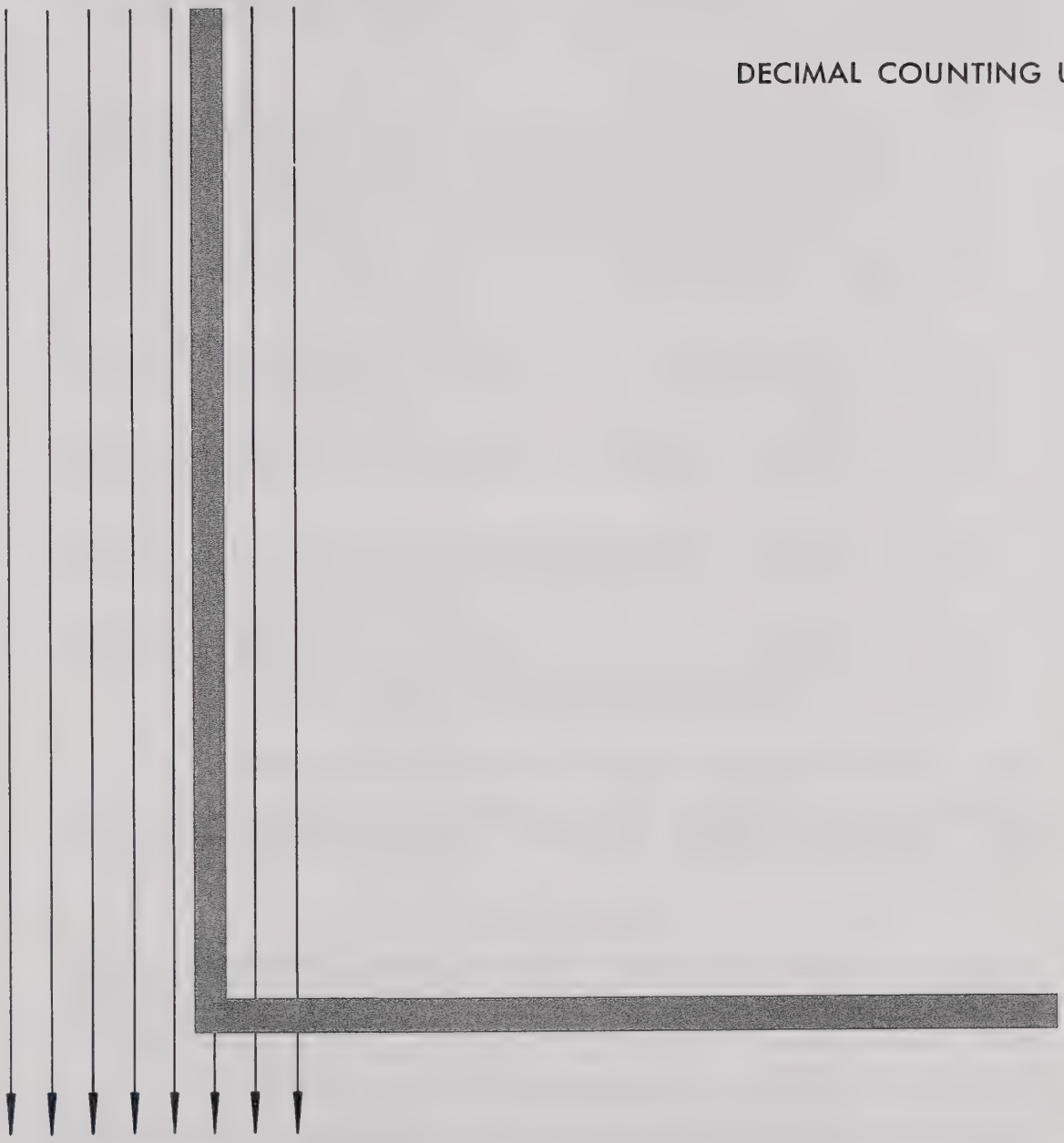


FIG. W. Circuit diagram for modification W.

INSTRUCTION MANUAL

Models 775, 775AJ
& 775K

DECIMAL COUNTING UNITS



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Appendix

Model 775R,
Dwg. No. C 402830

INTRODUCTION

These decimal counting units are direct-reading, plug-in electronic counters. The number of input pulses received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of these units can be connected in cascade (the output of one unit driving the next) forming a counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99,999 resetting to "00,000" on the 100,000th pulse.

Models 775 and 775K generate a binary coded decimal readout. This code is in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Direct reading, decimal presentation

Power Requirements

Heaters: 6.3 v. at 1.2 amps
Plates: 300 v. at 13 ma

Input Requirements

Negative pulses (see "OPERATION")

Output Characteristics

Designed to drive a Model 775 DCU or any modification except a 775LJ (i.e., 775AJ, 775K, etc.).

Resolution of Paired Pulses

5 microseconds

Reset

Will reset to either zero or nine depending on polarity of reset pulse applied.

Maximum Counting Rate

120,000 counts per second

Construction

Plug-in unit, 11-pin socket

OPERATION

Power Requirements. The heaters require 6.3 volts a-c at 1.2 amperes. The plate circuits may be operated on from 200 to 400 volts, although the design center is 300 volts at 13 ma. Plate voltage may be applied in the form of B + and B - voltages. The d-c level of all output voltages will depend upon the level of the plate supply voltages.

Input Requirements. A negative pulse at least two microseconds wide is required to drive the unit. The optimum pulse amplitude depends on the rise time. With a rise time of 0.5 microseconds (measured between ten and ninety percent values) the pulse amplitude should be between 75 and 135 volts. With a two-microsecond rise time, the amplitude should be between 120 and 165 volts. When operating the plate circuits on 300 volts, optimum performance is obtained with a rise time of one microsecond or less and a pulse amplitude of 100 volts. If the unit is powered by unregulated d-c supplies, the input pulse amplitude should vary in phase with the supply voltage. The input load presented when an input pulse occurs is 15K ohms in series with 100 picofarads ($\mu\mu$f).

Output Characteristics. The output is the rectangular waveform shown in Figure 3. As every tenth input pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4 of the DCU plug. With a plate supply of 300 volts, the potential at pin 4 drops from +135 to +55 volts with respect to B-. This transient can be used to drive succeeding decimal counting units or other circuitry. The load impedance connected

between the output terminal and ground must not be less than 300K or 6K in series with 100 picofarads.

Method of Resetting after a Counting Period. A DCU can be reset to a registered count of either zero or nine by the application of a voltage pulse of the proper polarity to the proper pin of the DCU plug. See the table below.

	RESET TO ZERO		RESET TO NINE	
	Pulse Polarity	Applied at Pin No.	Pulse Polarity	Applied at Pin No.
775	Neg.	8	Pos.	8
775AJ	Neg.	8	Pos.	8
	Pos.	3	Neg.	3
775K	Neg.	8	Pos.	8

The reset pin (or pins in the base of Model 775AJ) should be maintained at the B- supply voltage except when a reset pulse occurs. A 50-volt pulse at least 3μseconds wide is adequate. A 100-volt pulse need be only 1.5μseconds wide. There is no maximum pulse width; however the DCU will not begin counting again until the reset pin returns to the B- supply voltage.

Simply disconnecting a reset pin from B- with a switch or relay will have the same effect as applying a positive pulse.

Binary Code Readout. Models 775 and 775K generate a modified binary code representing the decimal digit registered. The code appears in the form of a voltage (high or low) at one plate of each of four double-triode binaries. In the table below, "0" represents a plate voltage of approximately +55 volts with respect to B-; "1" represents a plate voltage of about +135 volts with respect to B-. (These are the voltage levels which appear when using a 300-volt plate supply.) Each of the four plates is coupled to a pin of the DCU plug through a 1.2 megohm resistor except in the case of pin 4 on the 775K DCU. This pin is connected directly to a plate of the fourth binary. To obtain a readout voltage at this pin, it is necessary to add a 1.2M resistor externally.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Extinguishing the Indicating Lamps During the Counting Period. On Models 775 and 775K, it is possible to prevent the neon lamps from lighting by placing approximately +100 volts with respect to B- on pin 10 of the DCU plug. Ordinarily, the user will wish to extinguish the lamps while the DCU is actively counting, and to allow them to light, indicating the registered count, at the end of a counting period.

CIRCUIT DESCRIPTION

The Binaries. The decimal counting units contain four "flip-flop" circuits. These circuits are slightly modified versions of the Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut

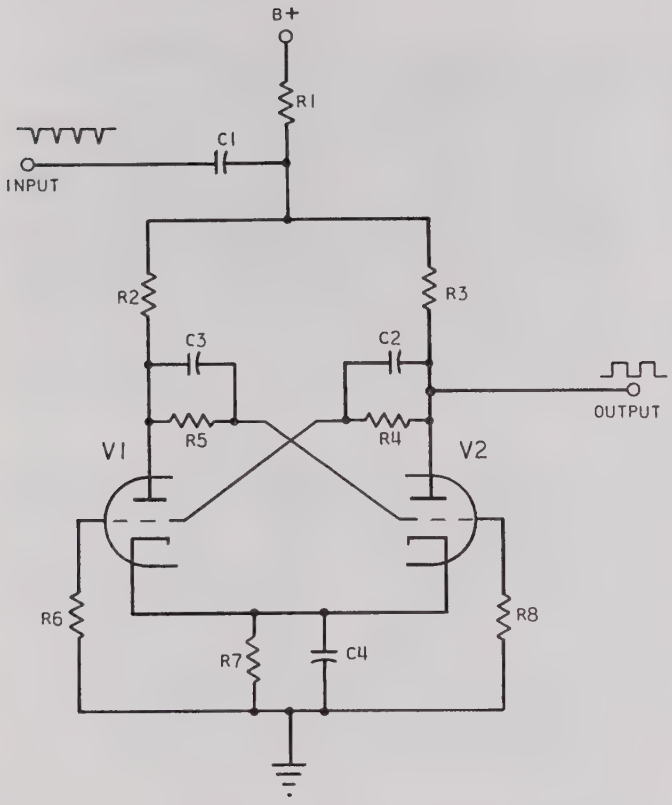


FIGURE 1. A TYPICAL BINARY.

off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R5 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R6, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative pulses applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a crossover network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale-of-two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next) a counter having a scale of any power of two can be built.

The Scale of Ten. In the Model 775 four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two positive feedback paths. (See Figures 2 and 3). For the first three negative input pulses, the unit operates like a simple binary counter. At the fourth input pulse, the third binary is triggered for the first time, sending a pulse through the first feedback path which triggers the second binary. Since it requires two input pulses to trigger the second binary, this is equivalent to adding two input pulses; therefore, the state of the unit now

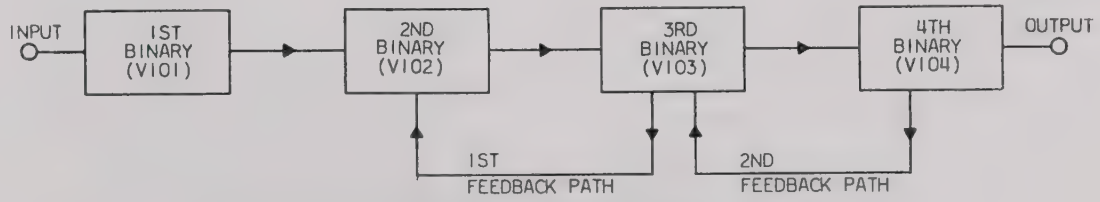


FIGURE 2. BLOCK DIAGRAM.

corresponds to a binary count of six. The sixth input pulse (equivalent to the eight in a simple binary chain) triggers the fourth binary which sends a pulse through the second feedback path, triggering the third binary. This is equivalent to adding four more input pulses so the state of the unit now corresponds to a binary count of 12. For the next four input pulses (7 thru 10) the unit operates again as a simple binary chain, producing an output pulse at the tenth input pulse. Adding the equivalent of six input pulses internally has changed the binary chain from a scale-of-16 to a scale-of-10.

When the third binary is triggered by a feedback pulse, it tends to retrigger the second binary in the same way that it did at the time of input pulse four. This tendency is offset by a simultaneous opposing signal from the fourth binary.

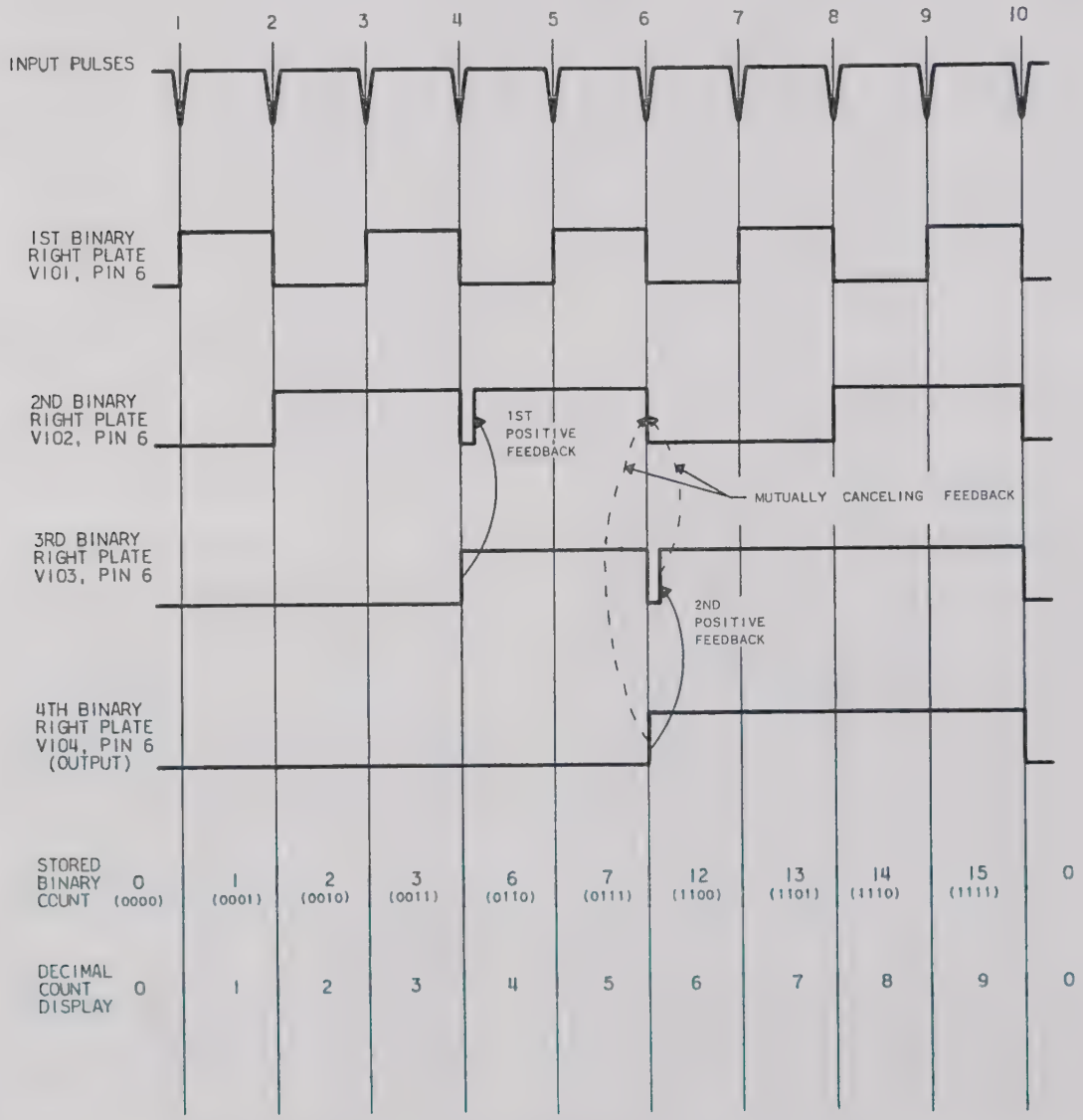


FIGURE 3. IDEALIZED WAVEFORMS. "RIGHT PLATE" REFERS TO THE PLATE APPEARING ON THE RIGHT-HAND SIDE OF THE BINARY AS DRAWN ON THE SCHEMATIC.

TROUBLESHOOTING PROCEDURES

When a decimal counting unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Because the counting unit is usually the indicating device of an instrument, it is often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate. The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4 & 5.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 200 to 400 volts is a rough indication of permissable tolerances.

TROUBLESHOOTING CHART

NOTE: Reset unit to zero before testing for symptoms

SYMPTOMS	POSSIBLE CAUSES
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Extraneous input signals. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Unit Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.

Unit counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.

1.	Unit skips every other number	(a) First stage defective. (b) Input circuit supplies double pulses.
2.	Two stable states per cycle.	(a) Second stage defective(Display sequence may be 01 or 45). (b) Loss of drive to second stage (01).
3.	Four stable states per cycle.	(a) Third stage defective (Display sequence may be 0123 or 6789). (b) Loss of drive to third stage (0123).
4.	Six stable states per cycle.	(a) Output excessively loaded (Display sequence may be 012345). (b) Last stage inoperative (Display sequence may be 1 012345 or $67^{89}_{23}89$*. (c) Loss of drive to fourth stage (Display sequence may be 012345).
5.	Eight stable states per cycle or any failure where two successive numbers are skipped.	(a) Second or third stage failure.
6.	Ten stable states per cycle, but the lighting sequence is incorrect.	(a) When the wrong neon lamp lights, the trouble is usually a defect in the lamp that should have lit, but it may be a defect in the lamp that lit improperly. It's also possible that more than one lamp will light in place of the correct one.
7.	Twelve stable states per cycle.	(a) When lighting sequence is $0123^{01}_{45}456789$* the cause may be a failure of the first feedback or lowered cathode emission in first or second binary. (b) When the lighting sequence is $01234567^{23}_{89}89$ the cause may be failure of the second feedback or low cathode emission in third or fourth binary.

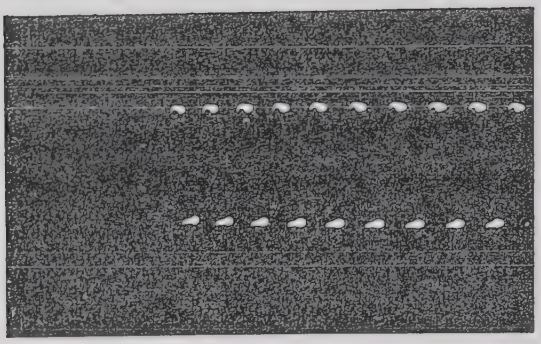
* One digit above another means both lamps are lit.

TABLE OF VOLTAGES & RESISTANCES

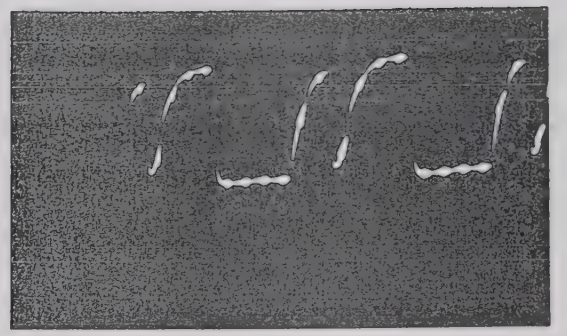
Tube	Pin No.	D-C Voltage with respect to B-.*	Resistance to B minus Terminal**
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

* Voltages measured in unit with 300-volt plate supply

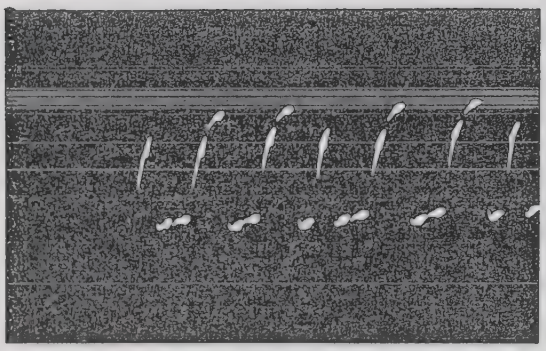
** Before making resistance measurements jumper pins 3 and 8 on the DCU plug.



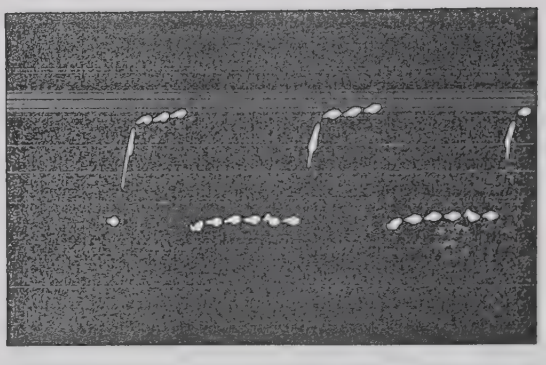
(1) First Binary Output (V101, Pin 6).
Upper voltage level is +168v
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.

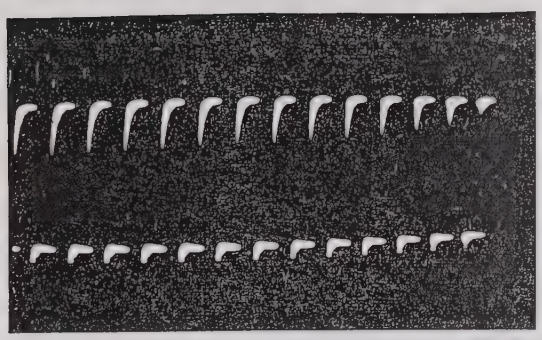


(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v.

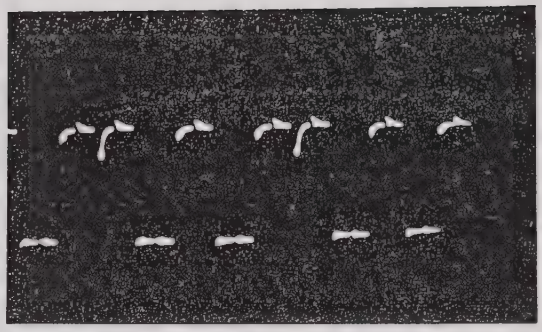


(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

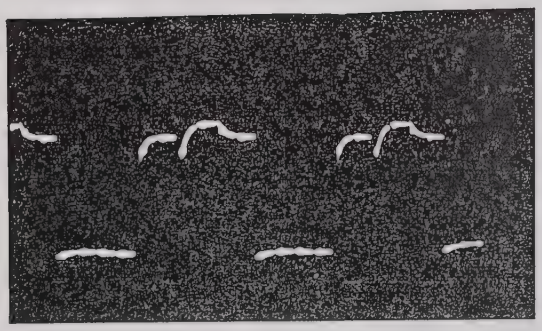
FIGURE 4. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 100KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.



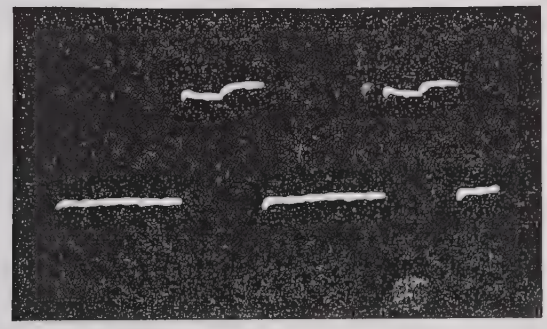
(1) First Binary Output (V101, Pin 6).
Upper Voltage level is +168V
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.



(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v



(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

FIGURE 5. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 20KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.

COMPONENT LOCATION GUIDE

REFERENCE NO.	COMPONENT BOARD LOCATION		
	MODEL 775 FIG. 7	MODEL 775 AJ FIG. 9	MODEL 775 K FIG. 11
C101	B 17	B 17	B 17
C102	B 18	B 18	B 18
C103	C 12	C 12	C 12
C104	C 7	C 7	C 7
C105	A 19	A 19	A 19
C106	A 21	A 21	A 21
C107	A 13	A 13	A 13
C108	A 15	A 15	A 15
C109	A 8	A 8	A 8
C110	A 10	A 10	A 10
C111	A 3	A 3	A 3
C112	A 5	A 5	A 5
C113*	A 17	A 17	A 17
C114*	A 12	A 12	A 12
C115*	A 7	A 7	A 7
C116*	A 2	A 2	A 2
C117	B 8	B 8	B 8
C118	C 6	C 6	C 6
C119	B 12	B 12	B 12
C120	-	D 2	-
CR101	-	D 20	D 20
CR102	-	D 18	D 19
R101	D 21	D 21	D 21
R102	D 17	D 17	D 17
R103	D 16	D 16	D 16
R104	D 15	D 15	D 15
R105	D 14	D 14	D 14
R106	D 13	D 13	D 13
R107	D 11	D 11	D 11
R108	D 8	D 8	D 8
R109	D 6	D 6	D 6
R110	D 5	D 5	D 5
R111	D 4	D 4	D 4
R112	D 3	D 3	D 3
R113	C 19	C 19	C 19
R114	C 14	C 14	C 14
R115	C 9	C 9	C 9
R116	C 4	C 4	C 4
R117	C 20	C 20	C 20
R118	C 17	C 17	C 17
R119	C 21	C 21	C 21
R120	C 18	C 18	C 18
R121	C 16	C 16	C 16
R122	C 13	C 13	C 13
R123	C 11	C 11	C 11
R124	C 8	C 8	C 8
R125	C 5	C 5	C 5
R126	C 3	C 3	C 3
R127	A 18	A 18	A 18
R128	A 20	A 20	A 20
R129	A 14	A 14	A 14
R130	A 16	A 16	A 16
R131	A 9	A 9	A 9
R132	A 11	A 11	A 11
R133	A 4	A 4	A 4
R134	A 6	A 6	A 6
R135	B 19	B 19	B 19
R136	B 20	B 20	B 20
R137	B 14	B 14	B 14
R138	B 15	B 15	B 15
R139	B 9	B 9	B 9
R140	B 10	B 10	B 10
R141	B 4	B 4	B 4
R142	B 5	B 5	B 5
R143	A 17	A 17	A 17
R144	A 12	A 12	A 12
R145	A 7	A 7	A 7
R146	A 2	A 2	A 2
R147	B 13	B 13	B 13
R148	C 10	C 10	C 10
R149	D 2	-	-
R150	D 7	-	D 7
R151	D 12	-	D 12
R152	D 18	-	D 18
R162	B 6	B 6	B 6
R163	-	D 9	-
R164	-	D 19	-

*Reverse side of board

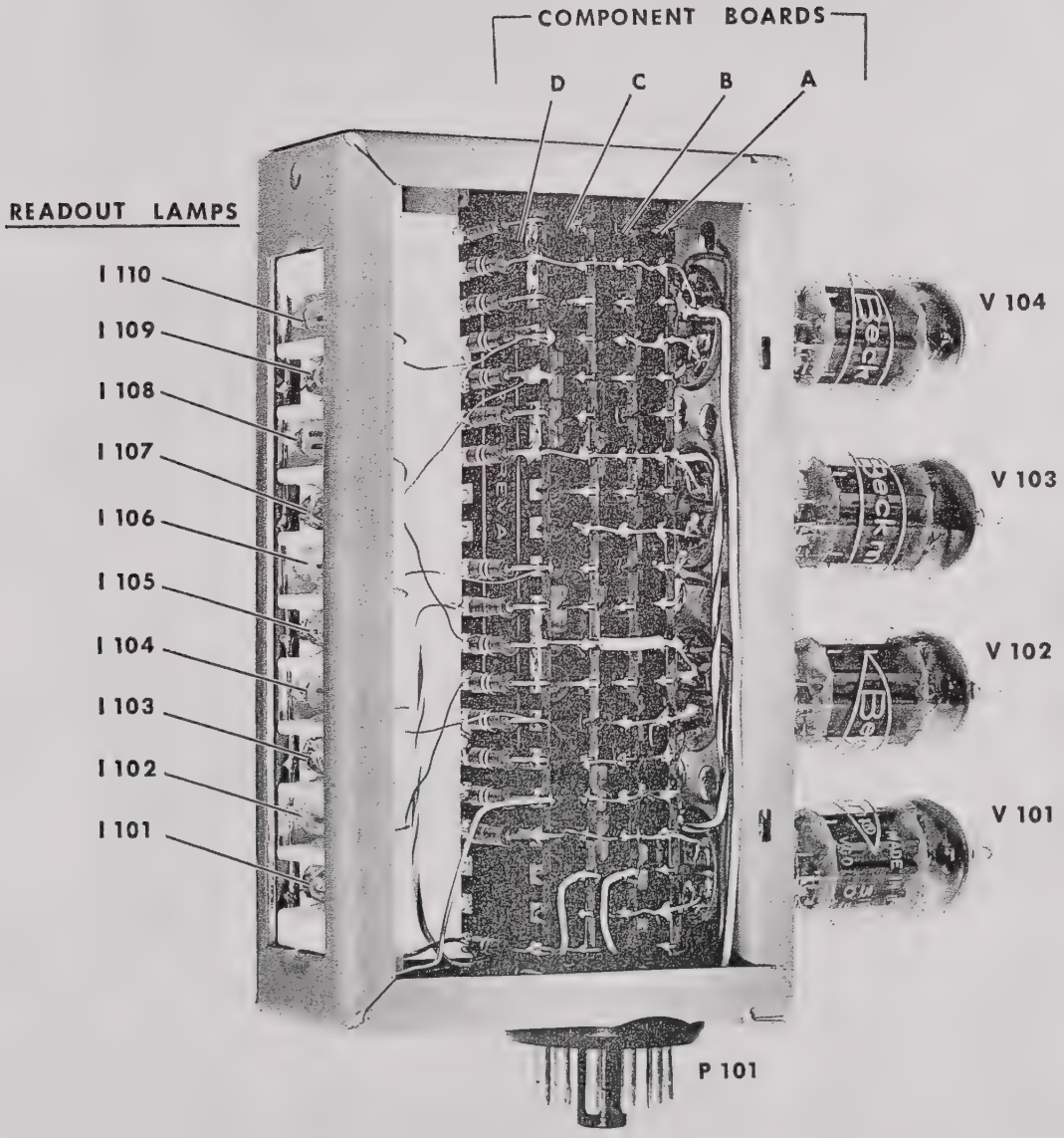


FIGURE 6. MODEL 775 DCU WITH NUMBER MASK REMOVED.

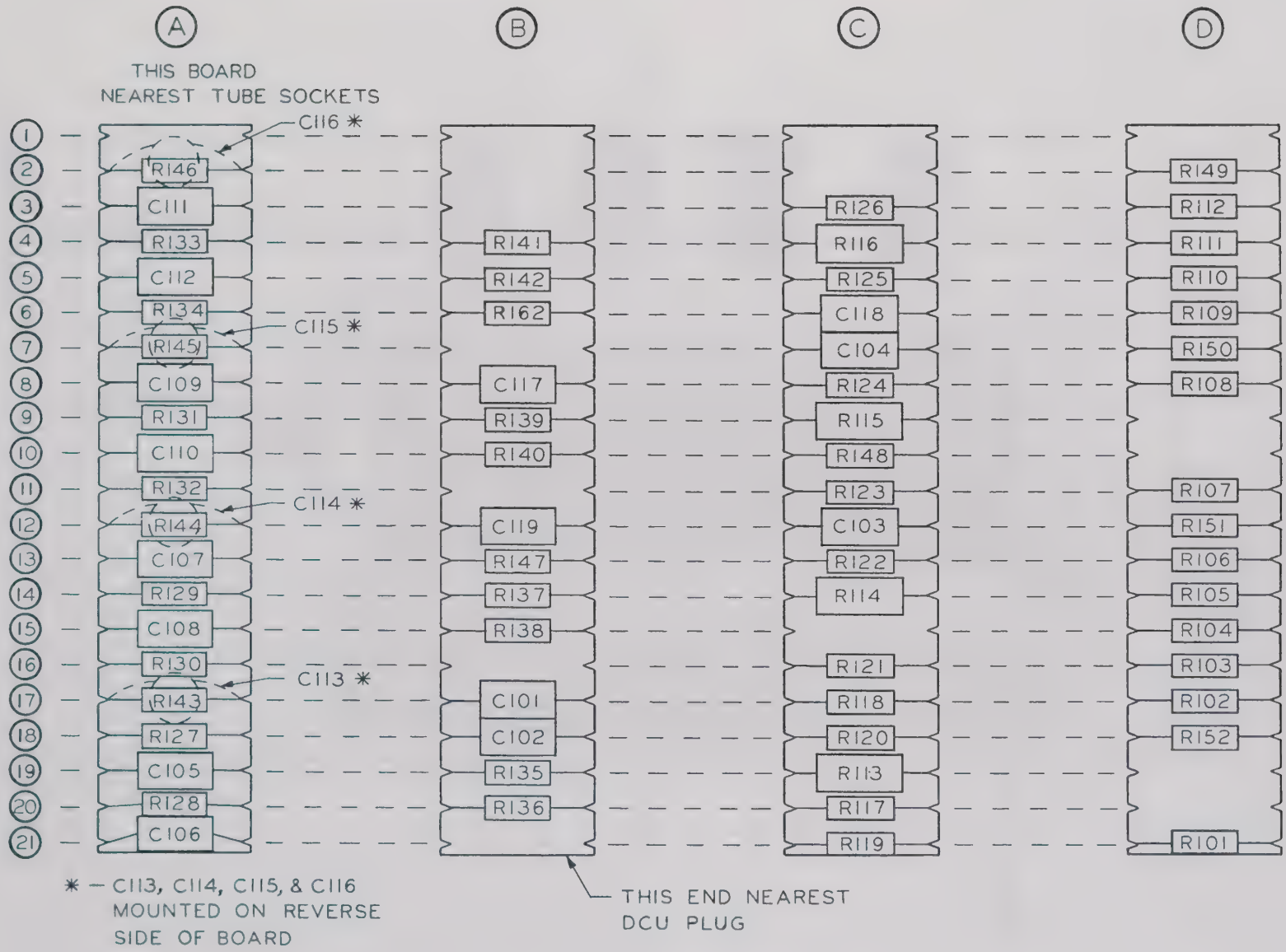
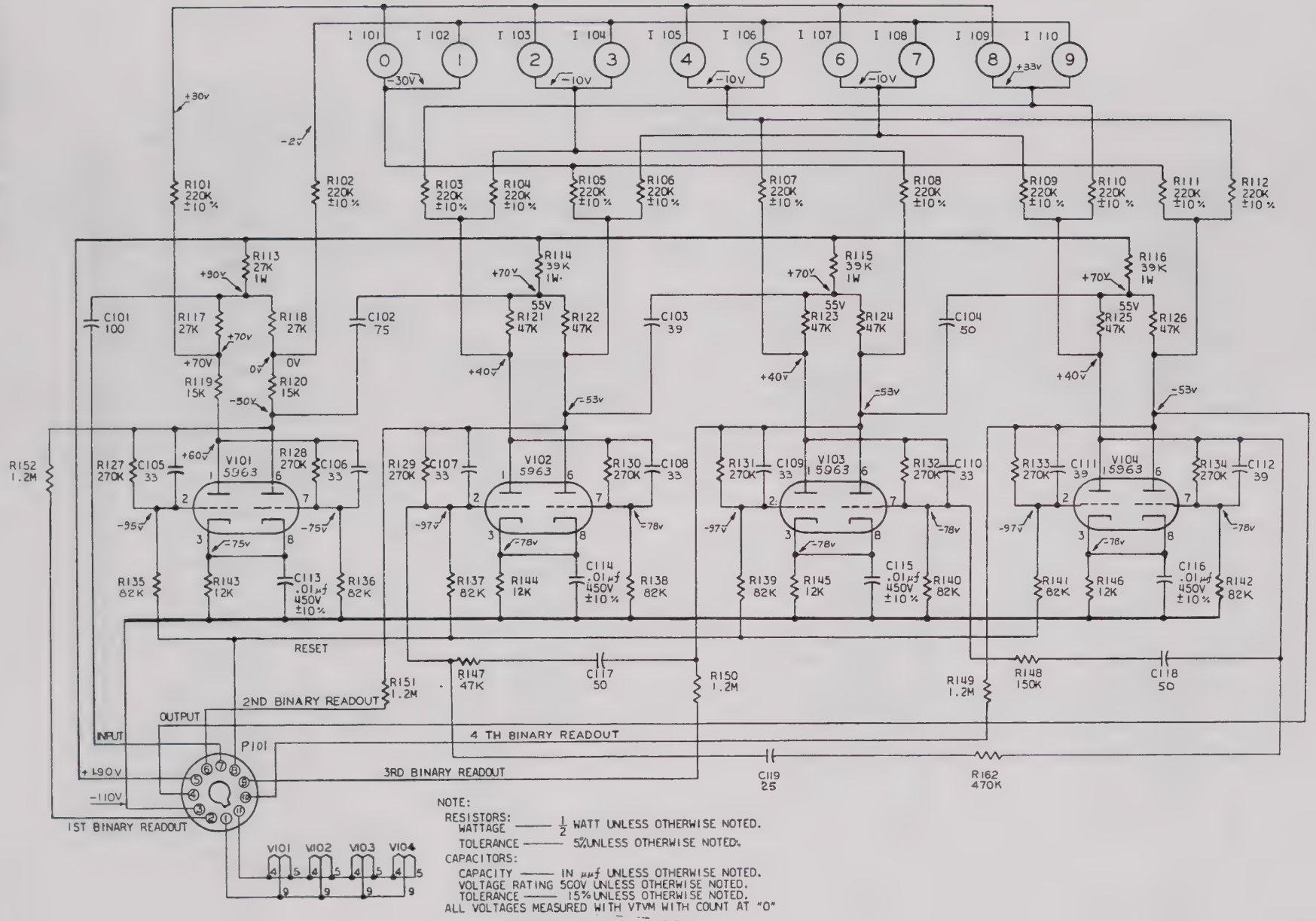


FIGURE 7. MODEL 775 COMPONENT BOARD LAYOUT.



NOTE:
RESISTORS: WATTAGE —— ½ WATT UNLESS OTHERWISE NOTED.
TOLERANCE —— 5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY —— IN µµf UNLESS OTHERWISE NOTED.
VOLTAGE RATING 500V UNLESS OTHERWISE NOTED.
TOLERANCE —— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0"

FIGURE 8. MODEL 775 SCHEMATIC DIAGRAM.

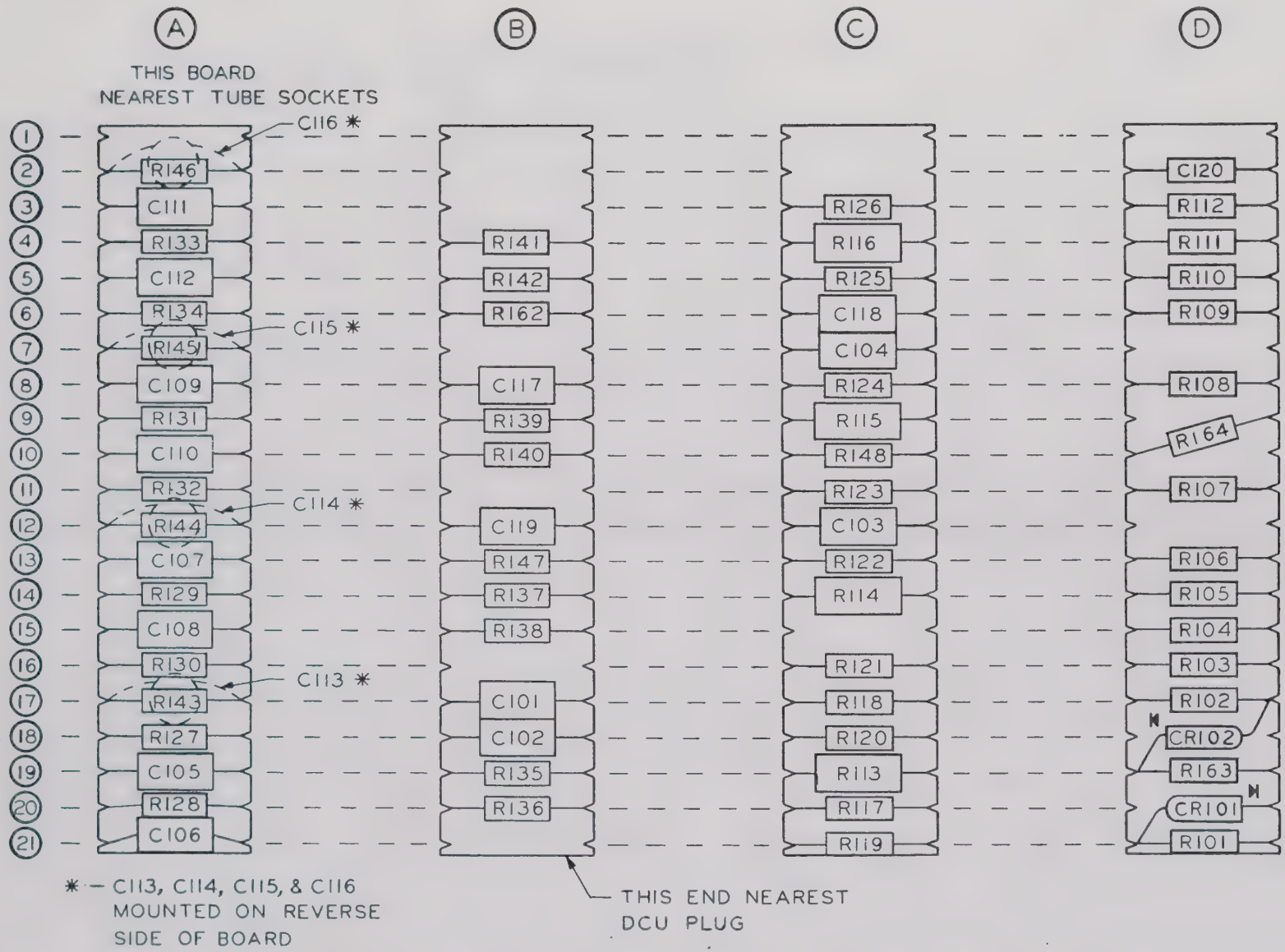
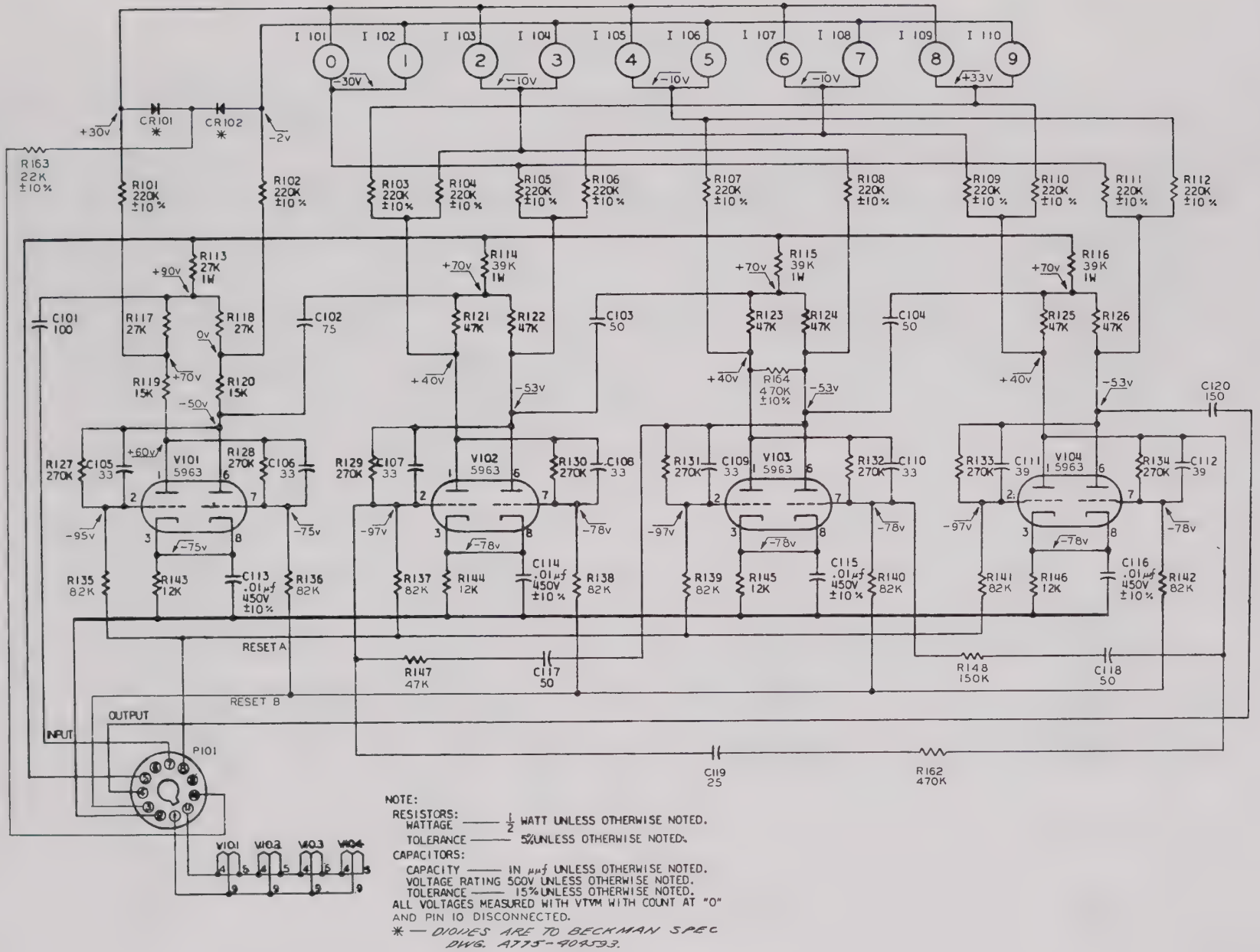


FIGURE 9. MODEL 775AJ COMPONENT BOARD LAYOUT.



NOTE:
RESISTORS: WATTAGE —— $\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE —— 5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY —— IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING 500V UNLESS OTHERWISE NOTED.
TOLERANCE —— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0" AND PIN 10 DISCONNECTED.
* — DIODES ARE TO BECKMAN SPEC DWG. A775-402593.

FIGURE 10. MODEL 775AJ SCHEMATIC DIAGRAM.

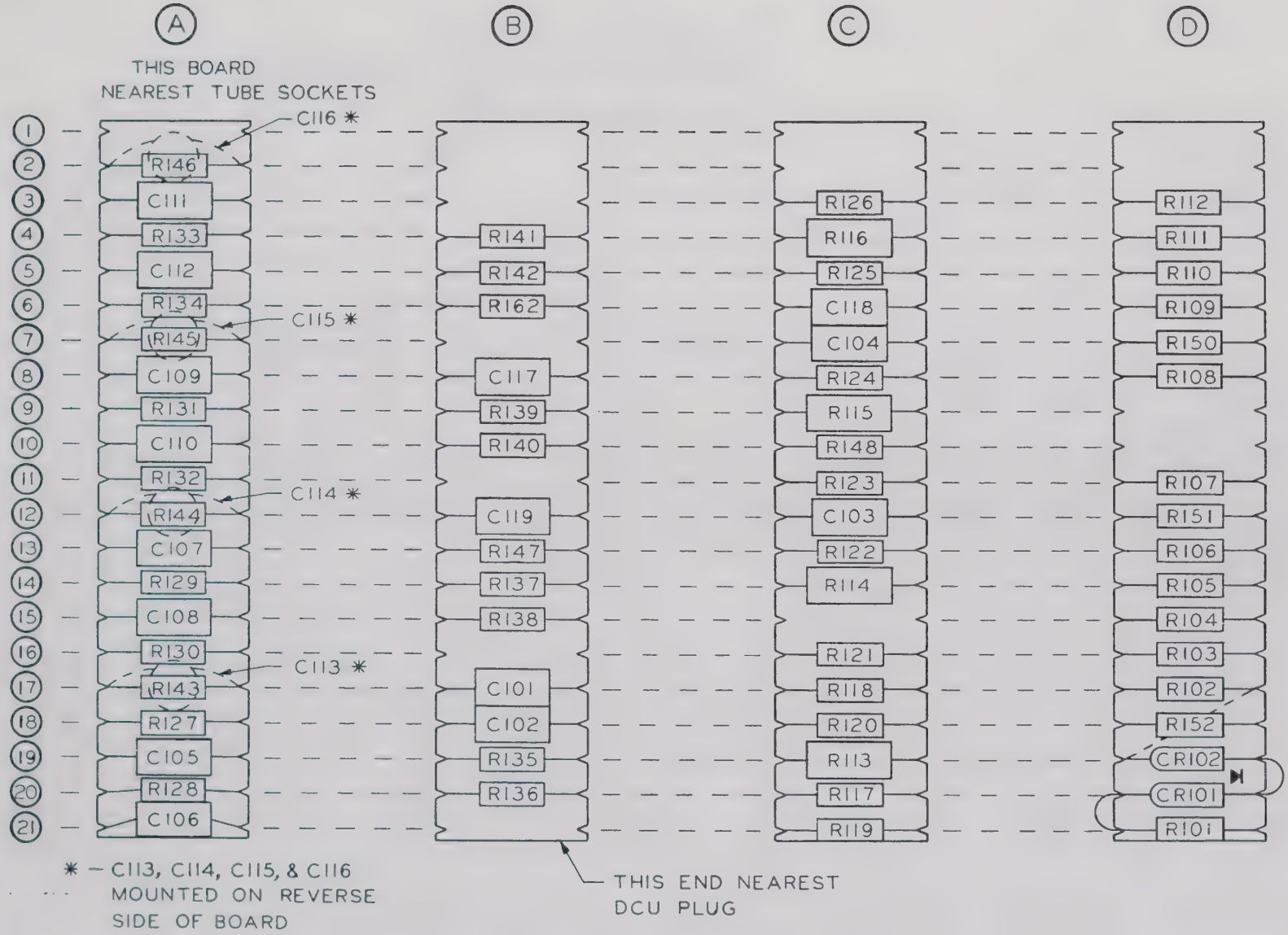


FIGURE 11. MODEL 775K COMPONENT BOARD LAYOUT.

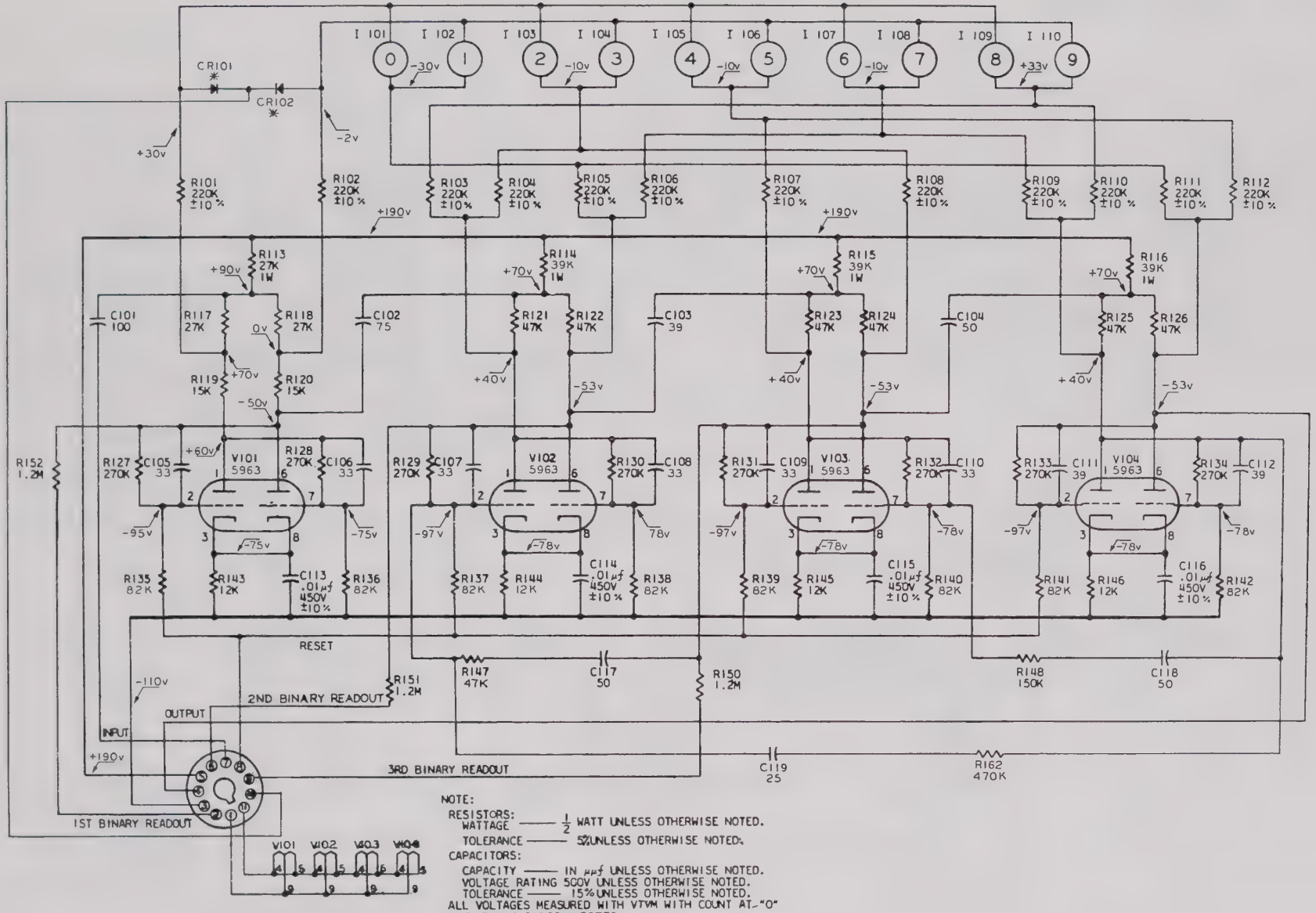
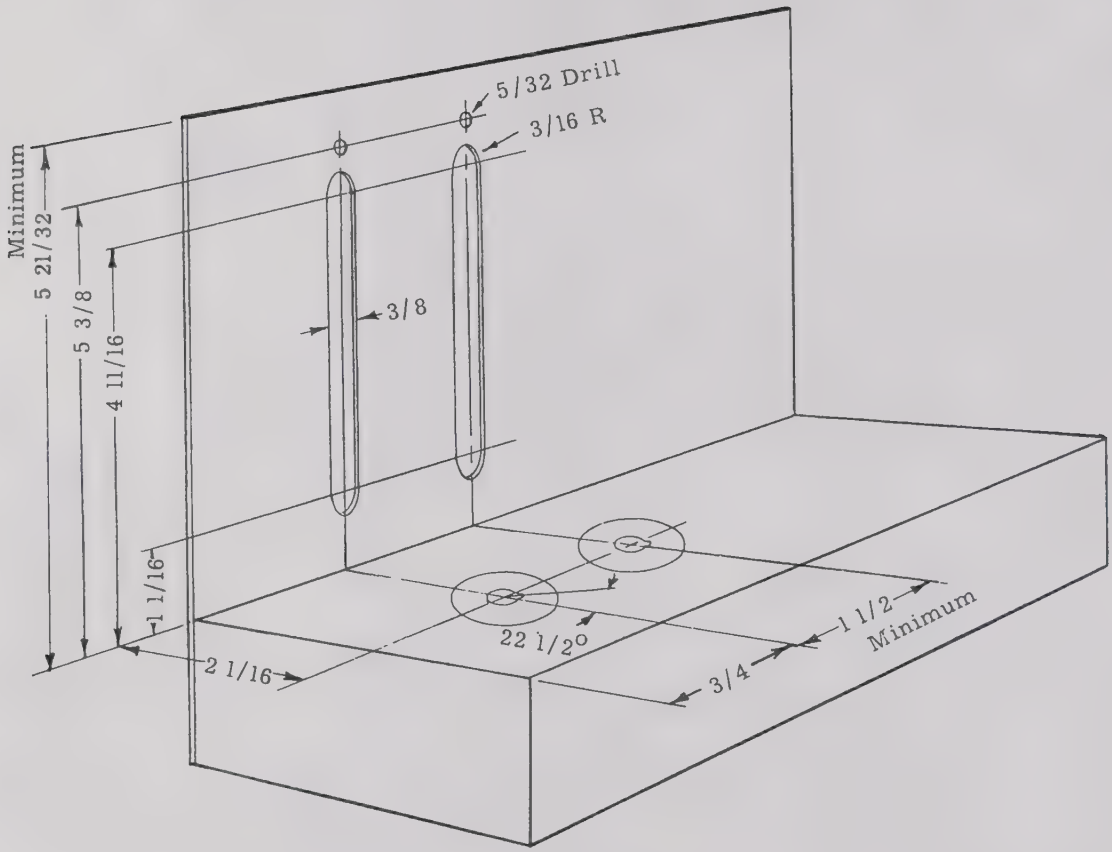


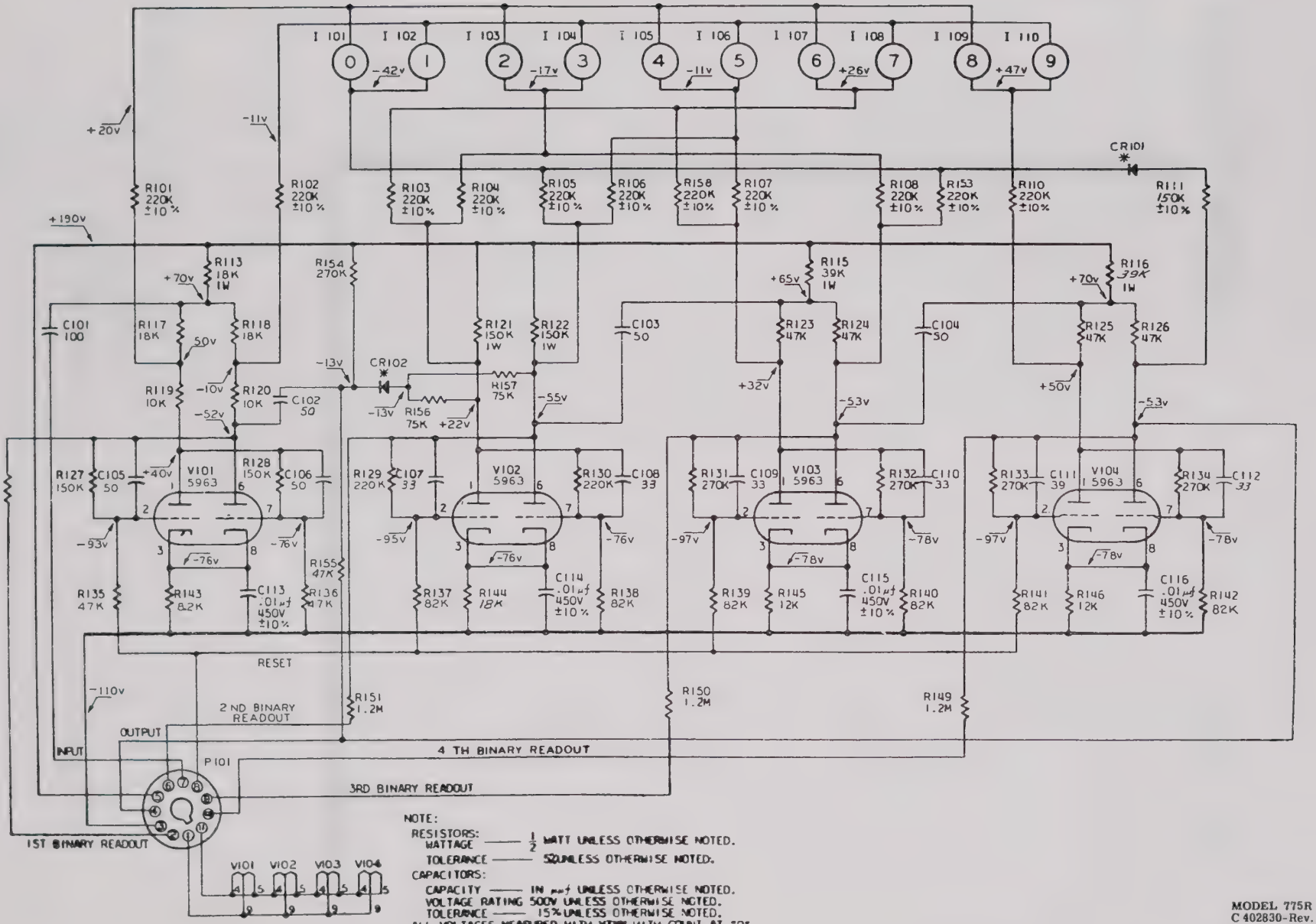
FIGURE 12. MODEL 775K SCHEMATIC DIAGRAM.



NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket mounted above the chassis.

FIGURE 13. MOUNTING DIMENSIONS FOR MODEL 775, 775AJ, AND 775K.

MODEL 775R DCU
SCHEMATIC DIAGRAM



NOTE:
RESISTORS: WATTAGE —— ½ WATT UNLESS OTHERWISE NOTED.
TOLERANCE —— 5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY —— IN μf UNLESS OTHERWISE NOTED.
VOLTAGE RATING 500V UNLESS OTHERWISE NOTED.
TOLERANCE —— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".
* —— DIODES ARE TO BECKMAN SPEC. PNO. A755-404503.

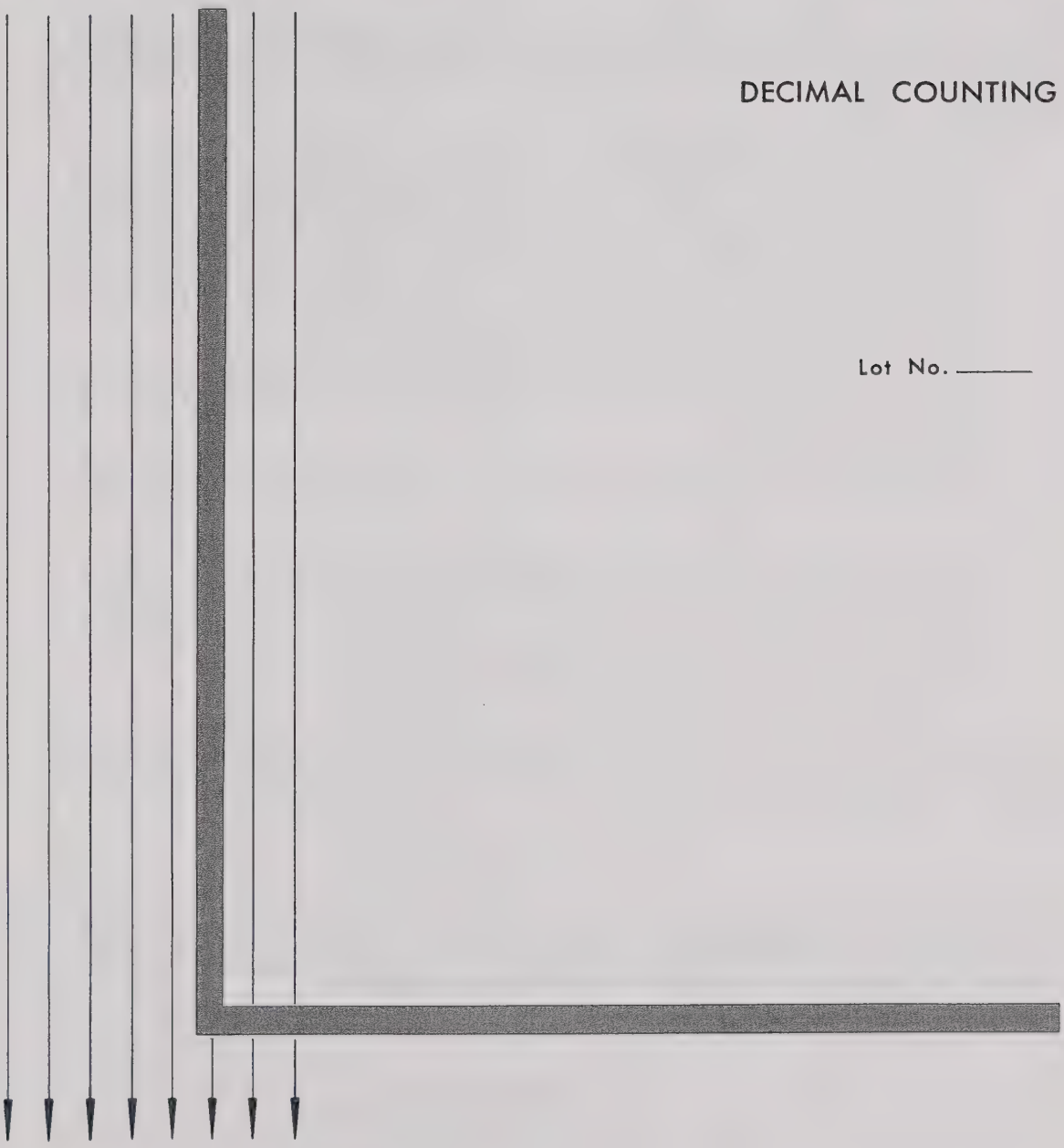
MODEL 775R
C 402830-Rev. I
July 1963

Beckman®

INSTRUCTION MANUAL

MODEL 785

DECIMAL COUNTING UNIT



Lot No. _____

Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

September 12 1957

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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GENERAL DESCRIPTION

The Model 785 is a direct-reading, plug-in decimal counting unit. A decimal counting unit (DCU) registers voltage pulses applied at an input. Starting from zero it counts to nine, returning to zero on the tenth pulse and simultaneously generating an output signal. The count score is indicated by the illumination of one of ten neon lights placed behind a numbered acetate panel. This unit will count at a maximum rate of 1,100,000 pulses per second. This output is suitable for driving the Model 705 DCU or any modification of it (705AH, 705AK etc.) Decimal counting units may be connected in cascade (output of one to input of next), thus forming a counter whose total capacity depends only on the number of units in the chain. For example, a chain consisting of one 785 followed by five 705AH's will count to 999,999, returning to "000,000" on the 1,000,000th input pulse.

The unit also generates a binary-coded decimal readout in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication
: Illuminated decimal digits

Input Requirements
: Negative pulses. (See "OPERATION")

Resolution of Paired Pulses
: 0.8 μseconds

Maximum Counting Rate
: 1,100,000 Counts-per-second

Output Characteristics
: Designed to drive a Model 705A DCU or any modification of it. (See "OPERATION".)

Reset
: Reset to zero by negative pulse applied to pin 8 of plug.

Power Requirements
: Heaters: 6.3V a-c at 1.8 amps near ground potential.

Plates:
: Plates: 175 to 260 volts. (Design center is 210 volts at 45 ma.)

Construction
: Plug-in unit which fits into standard 11-pin tube socket.

Dimensions
: 1-3/8" by 5-5/8" by 5-3/8"

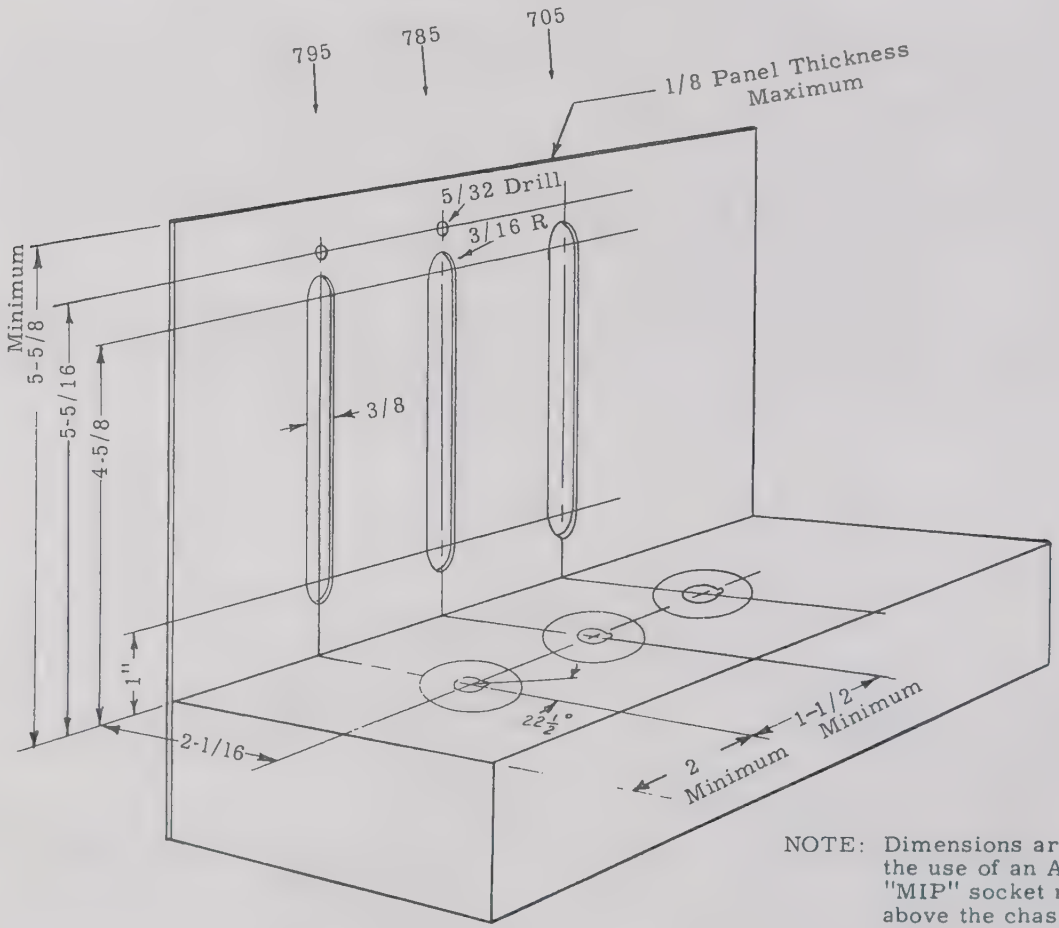
Weight
: 1 pound

Tube Complement
: Four type 12AV7.

INSTALLATION AND OPERATION

When purchased as part of another instrument, the decimal counting units are fully installed and ready to function. DCU's purchased separately should be installed and operated in accordance with the directions that follow.

Mounting. Figure 1 shows the dimensions of a chassis suitable for mounting one of these DCU's together with a Model 795 (10MC) and a Model 705 (100KC)



NOTE: Dimensions are based on the use of an Amphenol "MIP" socket mounted above the chassis.

The drawing shows the chassis dimensions for mounting Models 795, 785, and 705 DCU's side by side. Spacing between all units (or additional units) is identical.

FIGURE 1.

MOUNTING DIMENSIONS FOR MODEL 785 OR 795 DECIMAL COUNTING UNIT

INPUT REQUIREMENTS

A negative pulse of 7 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.12 microseconds, and the duration at least 0.25 microseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the actual B+ voltage.

OUTPUT CHARACTERISTICS

The output is a rectangular waveform as shown in Figure 4. It is represented at the output terminal as a change in direct current voltage level. During count display "0" thru "3" it is 115 volts; during count display "4" thru "9", 205 volts. Ordinarily, the 90-volt negative transient produced at the count of ten drives the following decimal counting unit.

The load imposed on a unit must not be more than a 27,000 ohm resistor in series with a 39 $\mu\mu$f capacitor to ground.

METHOD OF RESET

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 8 of the 11-pin socket.

BINARY CODE READOUT

The output at pins 2, 6, 9, and 10 of the DCU plug may be used to operate another binary coded readout or printing device. Refer to the Binary Readout Code table on page 6 to learn the relationship between binary digits and plug terminal pins.

CIRCUIT DESCRIPTION

THE BINARIES

The Model 785 DCU contains four "flip-flop" circuits referred to here as binaries. These circuits are modifications of the Eccles-Jordan trigger circuit.

Figure 2 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R3 and R7, holds this grid several volts below cut-off. Since small changes in the potential at the grid

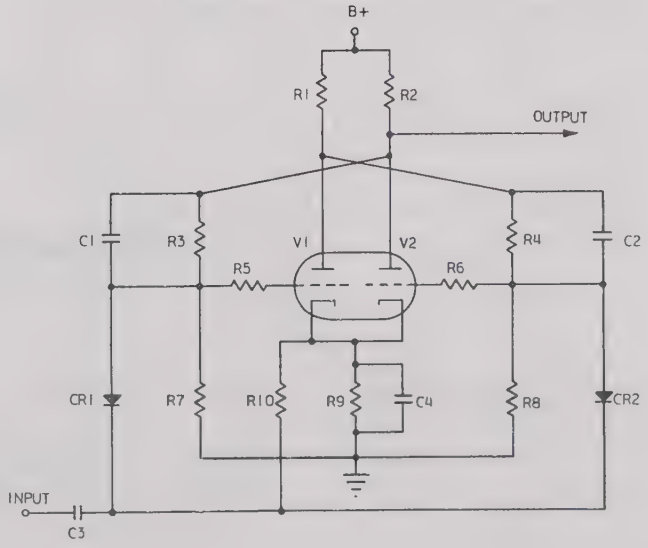


FIGURE 2.
A TYPICAL BINARY STAGE

of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative transients applied at the input. The input diodes CR1 and CR2 form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 40 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 30 volts. CR1 will not conduct since its plate is negative of 30 volts. However CR2 will conduct and the negative transient at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cut-off. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, re-enforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut-off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale of two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built. A chain of three cascaded binaries would be a scale-of-eight (2^3). If we call the input pulses driving such a chain "counts", the operation may be described as follows. The first binary will produce a negative pulse upon counts 2, 4, 6 and 8. The second binary will generate output pulses at counts 4 and 8, and the third binary will produce a pulse only at count 8. Count 8 completes a full cycle; the binaries will then be in the same state they were in before the first count.

THE SCALE OF TEN

In the Model 785 three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 3 is a block diagram of the circuit.

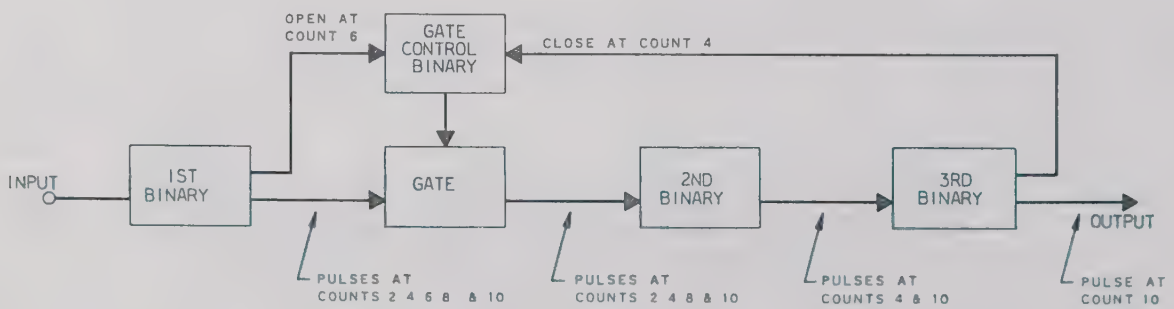


FIGURE 3.

BLOCK DIAGRAM OF MODEL 785 DCU

At the beginning of a cycle the gate control binary is in the state which holds the gate open. For the first three counts (that is, counts "1" through "3") the unit operates like a simple binary counter. At count 4 the third binary is triggered for the first time and, in turn triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse which triggers the gate control binary back to the "open" state. During counts 7, 8, 9, and 10 the unit again operates like a simple binary chain. At count 10 the third binary produces a negative output transient which will drive another decimal counting unit.

TABLE 1

Count Display	State of Each Binary Stage			
	4th	3rd	2nd	1st
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	1	1	0	0
5	1	1	0	1
6	0	1	0	0
7	0	1	0	1
8	0	1	1	0
9	0	1	1	1
0	0	0	0	0

The operating sequence of the DCU is summarized in Table 1 which shows the state of each binary for each registered count score. The state of a binary is defined by whether or not triode B is conducting. "0" means triode B is conducting; "1" means triode B is cut off.

Figure 4 shows how voltages throughout the unit change as successive input pulses are received. Voltages are identified by circled reference points located on the schematic diagram. The output voltage used to drive succeeding binaries is taken from the junction of two plate load resistors in the right-hand triode circuit rather than from the plate itself.

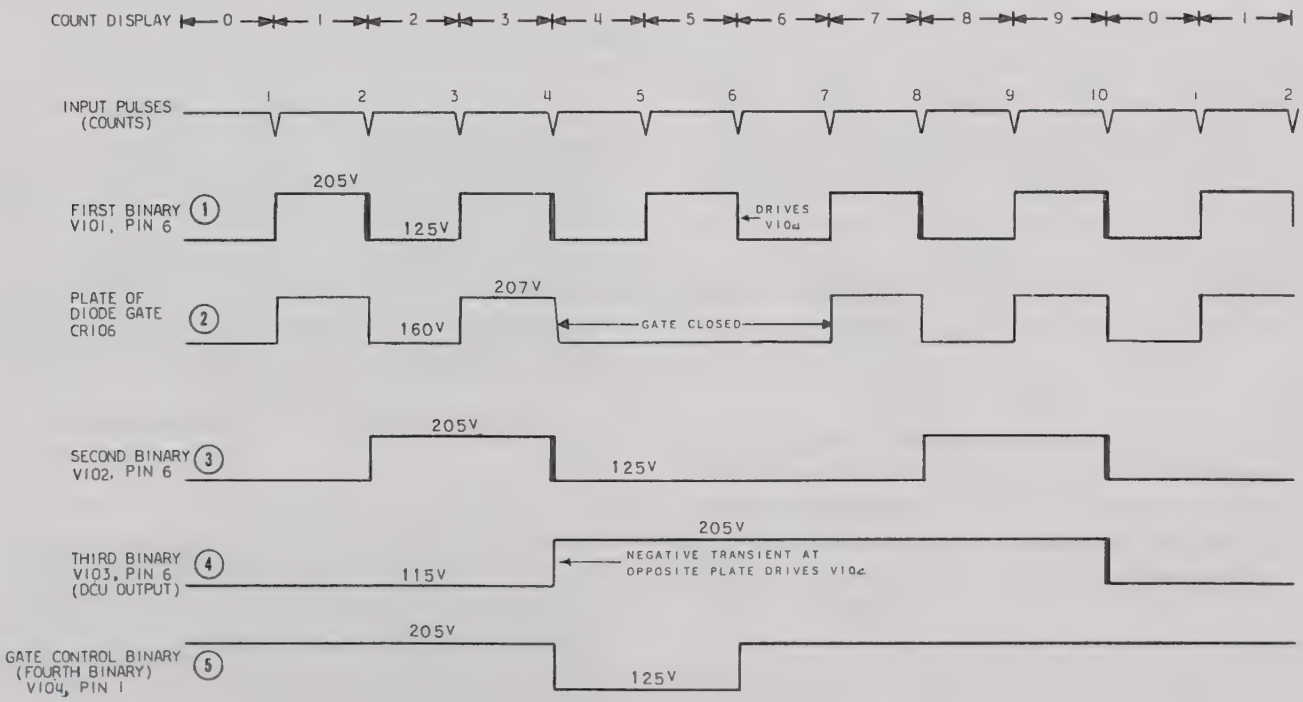


FIGURE 4. IDEALIZED WAVEFORMS

The waveforms at this junction are identical to the plate waveforms shown in figure 4, but of smaller amplitude. The negative transients (shown in heavy lines in Figure 4) drive succeeding binaries. The negative transient from the first binary which occurs at count 6 does not reach the second binary because of the action of the gate diode CR106 described in the paragraph "Gate Control Circuit."

Actual oscilloscope waveforms are shown in figure 8. Each photograph has a number corresponding to the point on the schematic diagram figure 9 where the waveform was observed.

BINARY CODE READOUT

The output voltages of each binary are also brought out to pins 2, 6, 9 and 10 of the DCU plug to operate auxiliary binary-coded readout devices. Observe that voltage at pin 6 combines the output of the second binary and the output of the right half of the fourth binary while the voltage at pin 10 combines the output of the third binary with that of the left half of the fourth binary. The resultant modified binary code given in Table 2 below agrees with that generated by other Beckman instruments. In the table, "0" represents a voltage of -15 volts or more negative; "1" represents a voltage at ground level or more positive.

TABLE 2 - BINARY READOUT CODE

Count Display	Pin on DCU Plug			
	10	9	6	2
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1
0	0	0	0	0

GATE CONTROL CIRCUIT

At count 4, the voltage at the right plate of the third binary (Point (4) on the schematic) rises. At the same time, the voltage at the left plate drops. The negative transient produced at the left plate is coupled to the right grid of the gate control binary (V104), causing it to switch to the state in which the left triode conducts. (Point (5)). The resultant voltage drop across R119 causes the plate of the diode gate (CR106) to drop to +160v. (Point (2)). At this time the diode plate voltage is equal to its cathode voltage, which varies between +207v and +160v. The diode does not conduct and therefore prevents the negative output transient at count 6 from reaching the second binary. However, the negative output pulse of V101 is coupled through C104 to the left grid of the control binary which now above cut-off. This switches the control binary back to its original stable state, opening the gate to pass a trigger pulse to the second binary at count 8.

OUTPUT CIRCUITRY

As the DCU cycles through counts "1" to "10", ten discreet combinations of binary states are produced, corresponding to the binary code given in the table on the preceding page. The output voltage of binaries #2 through #4 is at one of two levels which we shall designate "high" or "low". The outputs are connected to the neon bulbs in a matrix using diodes so that if one lamp terminal is connected to a low potential the voltage at that point will remain low regardless of the output level of another binary which may be connected to the same terminal. The output voltage of binary #1 is either "low" or "intermediate" because the voltage divider networks in the plate circuits prevent the voltage from reaching the "high" level.

At count "1" lamp No. 1 has both high and low potentials existing at its terminals. The circuit can be analyzed as in figure 5 for each count of the cycle in order to verify that this condition will exist for only one neon bulb at each count.

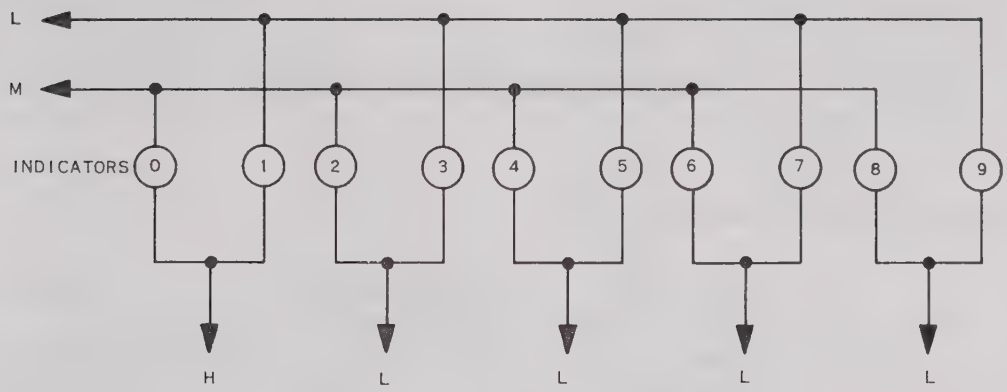


FIGURE 5.

VOLTAGE LEVELS ACROSS NEON
BULBS EXISTING AT COUNT ONE
(H= HIGH, M= INTERMEDIATE, L= LOW)

SERVICING

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

The Troubleshooting Chart (table 3) lists some common troubles which may be readily localized by observing the lighting patterns. Figure 8 shows actual oscilloscope waveforms to be used for comparison. Voltage and resistance measurements at tube pins are given in table 4.

It will be found that most failures are caused by faulty tubes.

TABLE 3

TROUBLESHOOTING CHART

NOTE: Reset unit before troubleshooting

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage
	(b) Input signal of insufficient amplitude
	(c) Input signal of wrong polarity
	(d) First stage inoperative
Unit counts spuriously	(a) Stray input signal
	(b) Pulses received through power supply
	(c) External voltages picked up by output lead
Units counts erratically	(a) Input signal too large or small, incorrect rise time
	(b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry
	(b) Defective component
Unit counts in wrong sequence	
1. Skips every other number	(a) First stage defective
	(b) Input circuit supplies double pulses
2. Skips 4 and 5	(a) 4th stage not being driven by the 3rd
3. Skips 6 and 7	(a) Defective gate diode (CR106)
Repeats a pattern of numbers	
1. Two stable states per cycle (0-1 or 2-3, etc.)	(a) 2nd stage not being driven
2. Four stable states per cycle (0-1-2-3 or 6-7-8-9)	(a) 3rd stage not being driven
3. Counts up to 5, then alternates between 4-5	(a) 4th stage not being driven by the 1st
Two lamps light simultaneously	Defective diode (CR101 to CR105)

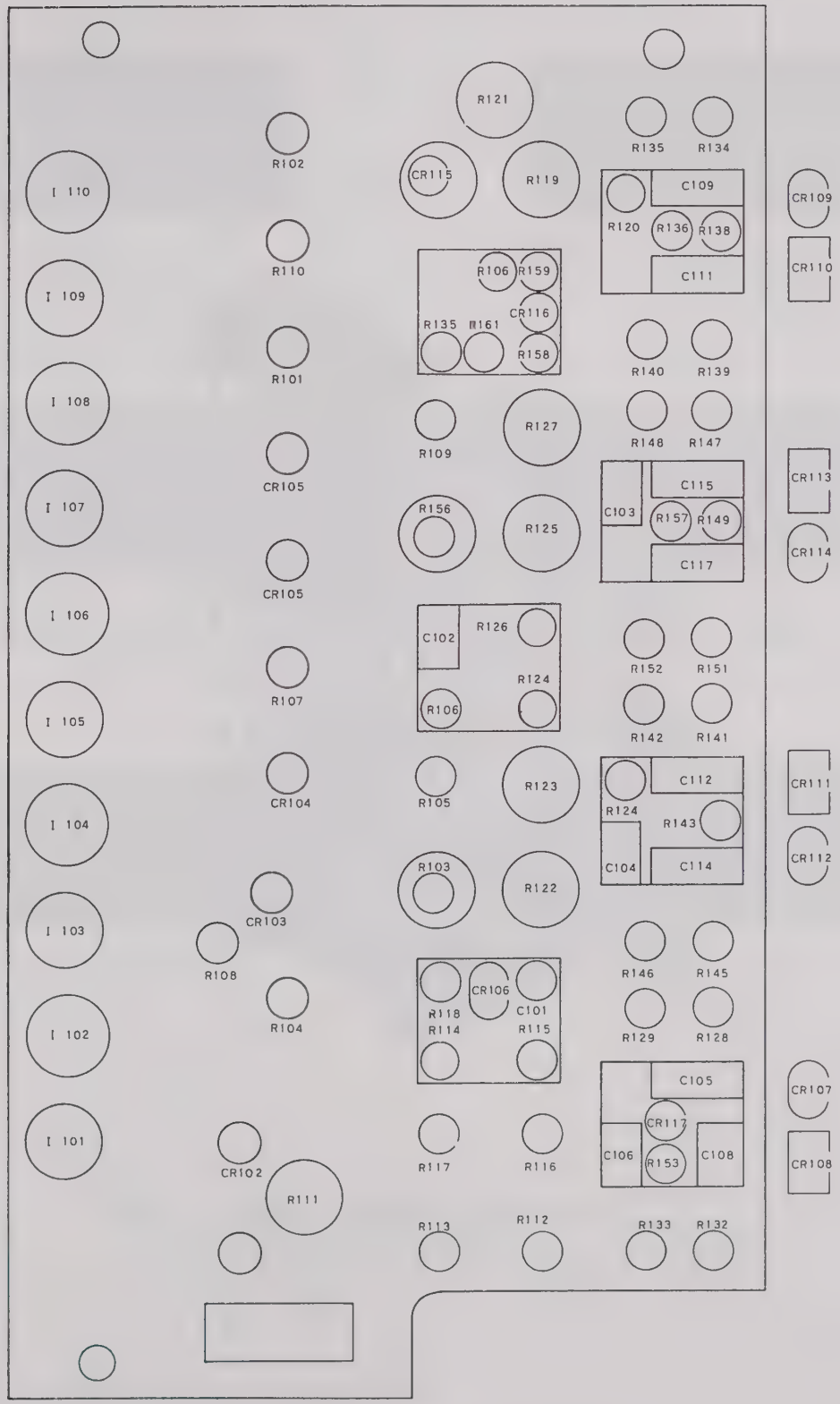
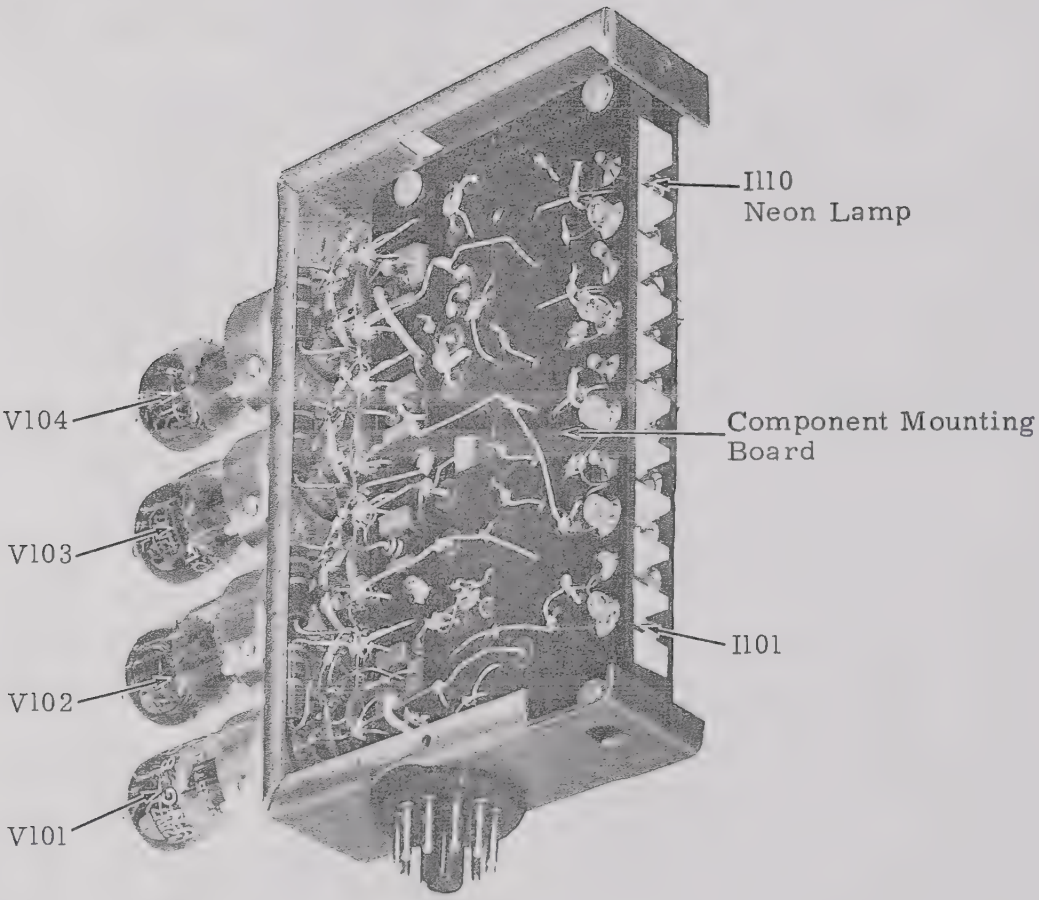


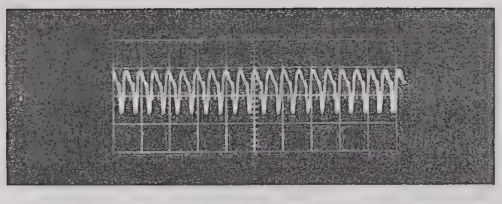
FIGURE 6.

PARTS LOCATIONS ON THE COMPONENT MOUNTING BOARD

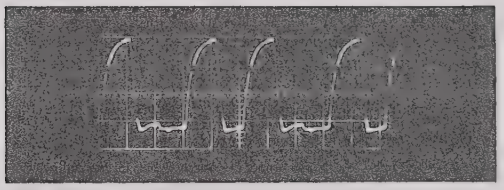


MODEL 785 DECIMAL COUNTING UNIT

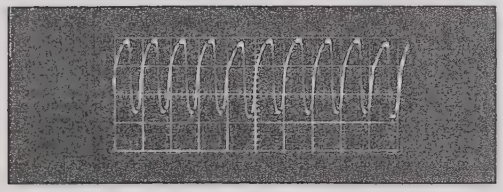
(All Panels Removed)



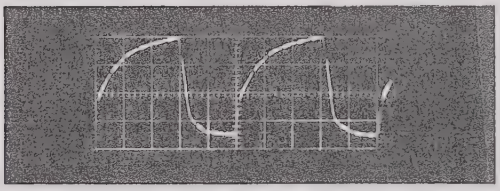
Input Pulses
8 volts peak-to-peak



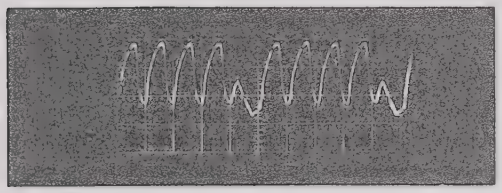
(3) Second Binary Output (V102, Pin 6)
65 volts peak-to-peak



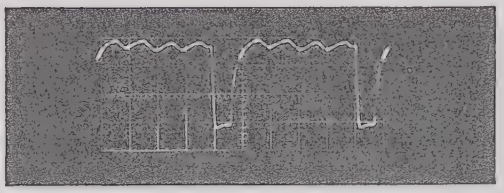
(1) First Binary Output (V101, Pin 6)
65 volts peak-to-peak



(4) Third Binary Output (V103, Pin 6)
65 volts peak-to-peak



(2) Plate of Gate Diode (CR106)
28 volts peak-to-peak



(5) Fourth Binary (V104, Pin 1)
62 volts peak-to-peak

FIGURE 8.
TYPICAL WAVEFORMS WITH INPUT FREQUENCY OF 1 MEGACYCLE. VOLTAGE LEVELS AT HIGH FREQUENCIES MAY DIFFER CONSIDERABLY FROM THOSE SHOWN IN FIGURE 4. (TIME SCALE = 2μSECONDS/CM)

VOLTAGES

Table 4a

Note: Voltages measured to ground at count "0" with a vacuum tube voltmeter such as an RCA Volt-ohmyst Senior. B+ voltage is 200 volts.

Tube	Voltages at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	+170	+42	+56	0	0	+104	+56	+56	6.3AC
V102	+170	+38	+52	0	0	+94	+52	+52	6.3AC
V103	+170	+19	+32	0	0	+78	+33	+32	6.3AC
V104	+170	+37	+50	0	0	+92	+53	+50	6.3AC

RESISTANCES

Table 4b

Note: Resistances are measured to chassis ground with the DCU removed from its socket.

Tube	Resistances at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	23K	33K	7K	∞	∞	25K	26K	7K	∞
V102	26K	18K	5.8K	∞	∞	26K	15K	5.8K	∞
V103	25K	11K	3.4K	∞	∞	24K	11K	3.4K	∞
V104	26K	21K	6K	∞	∞	26K	17K	6K	∞

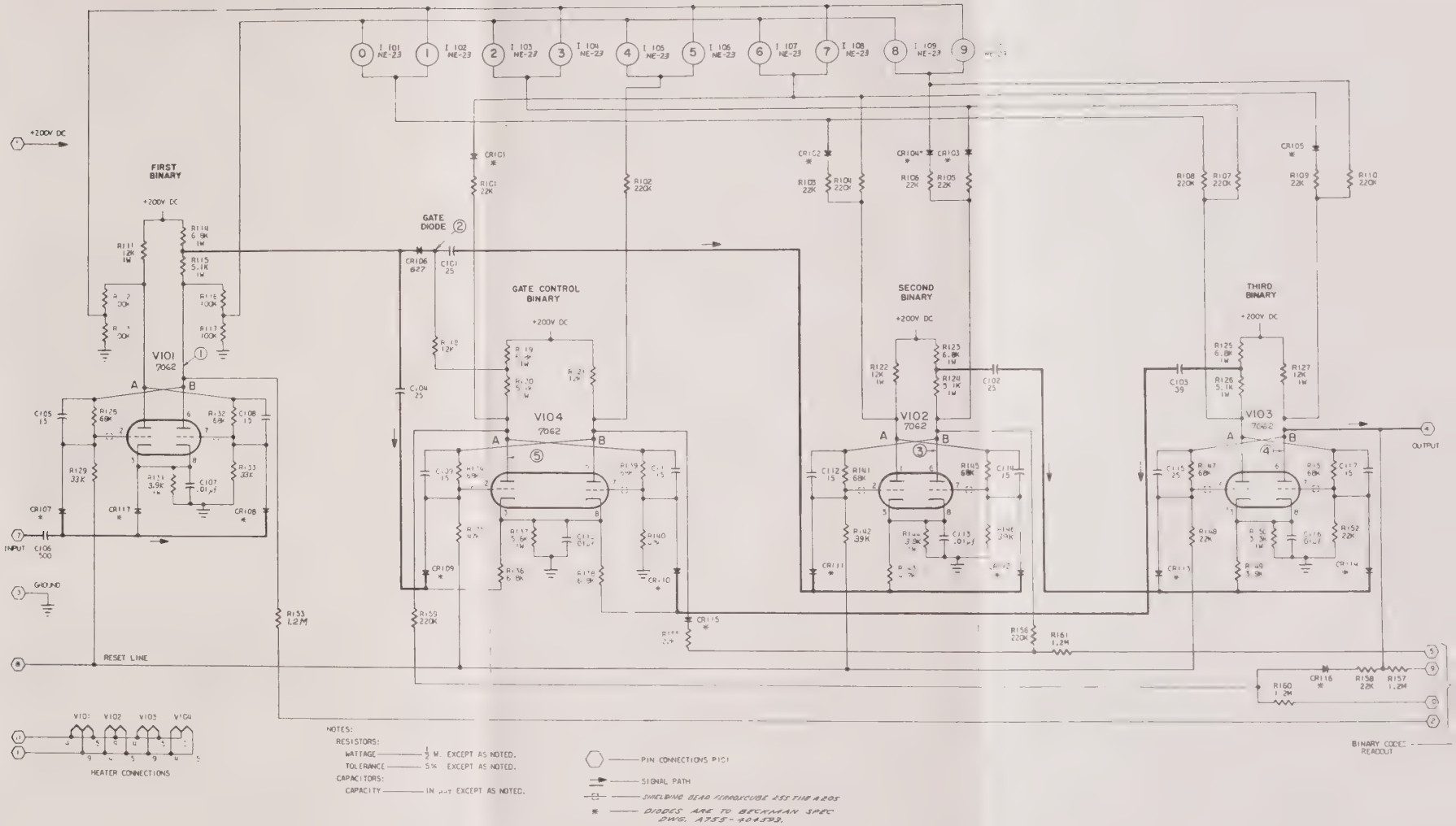
PARTS LIST

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty.
C101	633-804668	Capacitor, 25pf, Tubular Ceramic	Erie GP1K	1
C102	637-804741	Capacitor, 24pf, Silvered Mica	Sangamo	3
C103	637-804745	Capacitor, 39pf, Silvered Mica	Sangamo DR1433	1
C104		Same as C102		
C105	637-804738	Capacitor, 15pf, Silvered Mica	Sangamo DR1415	7
C106	637-804777	Capacitor, 500pf, Silvered Mica	Sangamo RR1350	1
C107	633-804717	Capacitor, 0.01μf, Disc, Axial Leads	Sprague S52564	4
C108 & C109		Same as C105		
C110		Same as C107		
C111 & C112		Same as C105		
C113		Same as C107		
C114		Same as C105		
C115		Same as C104		
C116		Same as C107		
C117		Same as C105		
CR101	755-404593	Diode, Special	Beckman/Berkeley	7
CR102 thru CR105		Same as CR101		
CR106	755-818178	Diode, 1N627, Standard	Hughes 1N627	1
CR107	755-404593	Diode, Special	B/B	9
CR108 thru CR114		Same as CR107		
CR115 & CR116		Same as CR101		
CR117		Same as CR107		
I101	825-815972	Lamp, 1/25W, Wire Leads, Neon	G.E. NE23	10
I102 thru I110		Same as I101		
P101	678-806896	Receptable, 11-pin Plug	Amphenol 86CP11	1
R101	601-000565	Resistor, F. Comp., 22k, 1/2W, 5%	Allen Bradley EB2235	9
R102	601-015083	Resistor, F. Comp., 220k, 1/2W, 5%	Allen Bradley EB2245	7
R103		Same as R101		
R104		Same as R102		
R105 & R106		Same as R101		
R107 & R108		Same as R102		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty.
R109		Same as R101		
R110		Same as R102		
R111	601-043210	Resistor, F. Comp., 12k, 1W, 5%	Allen Bradley GB1235	4
R112	601-015074	Resistor, F. Comp., 100k, 1/2W, 5%	Allen Bradley EB1045	4
R113		Same as R112		
R114	601-015197	Resistor, F. Comp., 6.8k, 1W, 5%	Allen Bradley GB6825	4
R115	601-001389	Resistor, F. Comp., 5.1k, 1W, 5%	Allen Bradley EB5125	4
R116 & R117		Same as R112		
R118	601-029323	Resistor, F. Comp., 12k, 1/2W, 5%	Allen Bradley EB1235	1
R119		Same as R114		
R120		Same as R115		
R121 & R122		Same as R111		
R123		Same as R114		
R124		Same as R115		
R125		Same as R114		
R126		Same as R115		
R127		Same as R111		
R128	601-015070	Resistor, F. Comp., 68k, 1/2W, 5%	Allen Bradley EB6835	8
R129	601-015060	Resistor, F. Comp., 33k, 1/2W, 5%	Allen Bradley EB3335	2
R131	601-079586	Resistor, F. Comp., 3.9k, 1W, 5%	Allen Bradley EB3925	2
R132		Same as R128		
R133		Same as R129		
R134		Same as R128		
R135	601-015064	Resistor, F. Comp., 47k, 1/2W, 5%	Allen Bradley EB4735	2
R136	601-010942	Resistor, F. Comp., 6.8k, 1/2W, 5%	Allen Bradley EB6825	2
R137	601-008847	Resistor, F. Comp., 5.6k, 1W, 5%	Allen Bradley EB5625	1
R138		Same as R136		
R139		Same as R128		
R140		Same as R135		
R141		Same as R128		
R142	601-015062	Resistor, F. Comp., 39k, 1/2W, 5%	Allen Bradley EB3935	2
R143	601-000899	Resistor, F. Comp., 4.7k, 1/2W, 5%	Allen Bradley EB3325	1
R144		Same as R131		
R145		Same as R128		
R146		Same as R142		
R147		Same as R128		
R148		Same as R101		
R149	601-015047	Resistor, F. Comp., 3.9k, 1/2W, 5%	Allen Bradley EB3925	1
R150	601-800065	Resistor, F. Comp., 3.3k, 1W, 5%	Allen Bradley EB3325	1
R151		Same as R128		
R152		Same as R101		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty.
R153	601-013194	Resistor, F. Comp., 1.2M, 1/2W, 5%	Allen Bradley EB1255	4
R155		Same as R101		
R156		Same as R102		
R157		Same as R153		
R158		Same as R101		
R159		Same as R102		
R160 & R161		Same as R153		
V101	751-828191	Tube, 7062	Sylvania	4
V102 thru V104		Same as V101		
XV101	860-802350	Tube Socket, 9-Pin Min., w/o Shield Base w/Center Shield	Elco 274 BC	4
XV102 thru XV104		Same as XV101		

SCHEMATIC DIAGRAM
MODEL 785
DECIMAL COUNTING UNIT

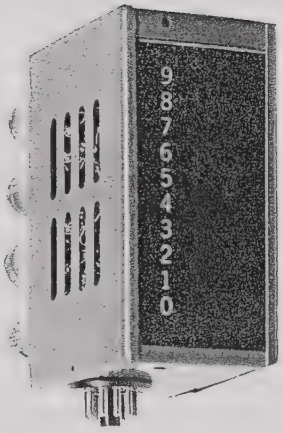


Beckman

INSTRUCTION MANUAL

MODEL 795

DECIMAL COUNTING UNIT



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June 1958

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GENERAL DESCRIPTION

The Model 795 is a direct-reading, plug-in decimal counting unit. A decimal counting unit (DCU) registers voltage pulses applied at an input. Starting from zero it counts to nine, returning to zero on the tenth pulse and simultaneously generating an output signal. The count score is indicated by the illumination of one of ten neon lights placed behind a numbered acetate panel. This unit will count at a maximum rate of 11,000,000 pulses per second. The output is suitable for driving the Model 785 DCU, which will in turn drive a Model 705A or any modification of it (705AH, 705AK etc.) Decimal counting units may be connected in cascade (output of one to input of next), thus forming a counter whose total capacity depends only on the number of units in the chain. For example, a chain consisting of a 795 followed by one 785 and five 705AH's will count to 9,999,999 returning to "0,000,000" on the 10,000,000th input pulse.

The unit also generates a binary-coded decimal readout in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Illuminated decimal digits

Input Requirements

Negative pulses. (See "OPERATION")

Resolution of Paired Pulses

0.09 μseconds

Maximum Counting Rate

11,000,000 Counts-per-second

Output Characteristics

Designed to drive a Model 785 DCU (See "OPERATION".)

Reset

Reset to zero by negative pulse applied to pin 8 of plug.

Power Requirements

Heater Supply: 6.3V a-c at 2.2 amps near ground potential.

B- Supply: -110 volts at 80ma applied at pin 3.
B+ Supply: +120 volts at 15ma applied at pin 7.
(The B+ supply voltage is superimposed on the input signal.)

Construction

Plug-in unit which fits into standard 11-pin tube socket.

Dimensions

2-1/2" by 5-5/8" by 5-3/8"

Weight

1.5 lbs.

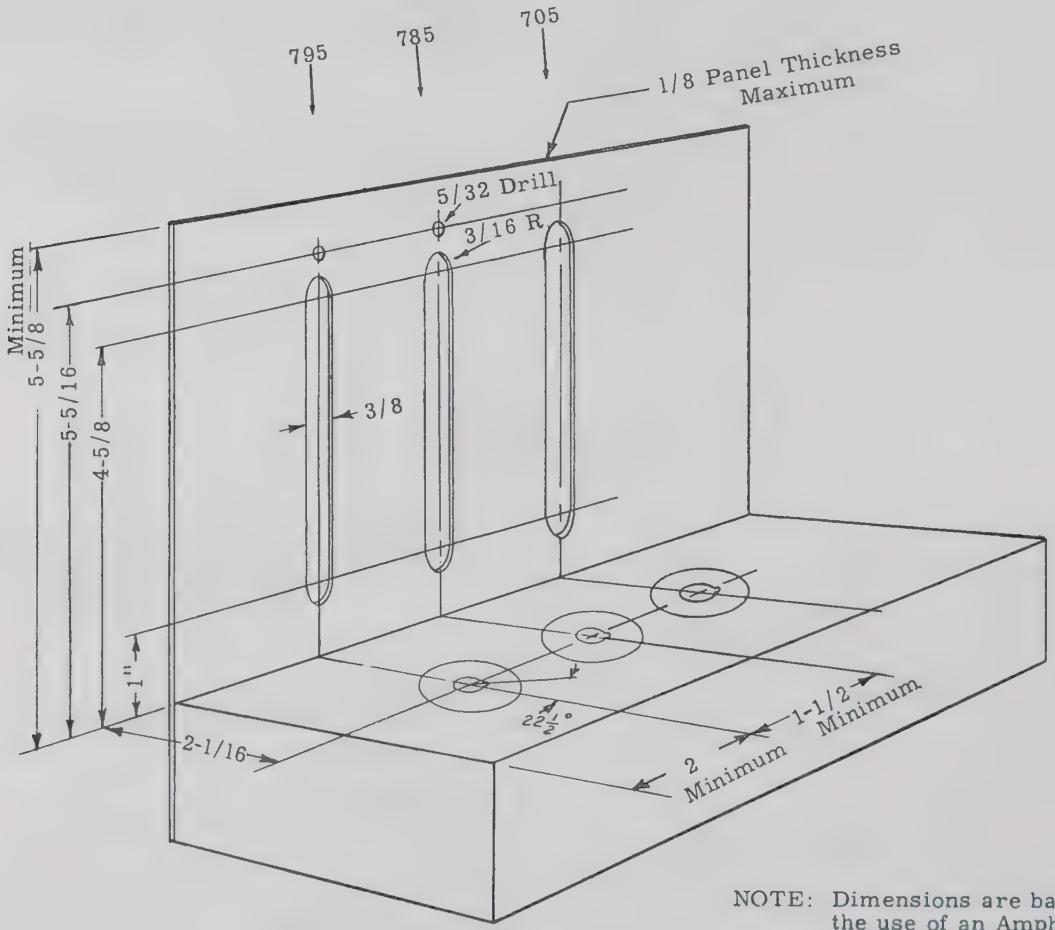
Tube Complement

4 type 6922
2 type 5964

INSTALLATION & OPERATION

When purchased as part of another instrument, the decimal counting units are fully installed and ready to function. DCU's purchased separately should be installed and operated in accordance with the directions that follow.

Mounting. Figure 1 shows the dimensions of a chassis suitable for mounting one of these DCU's together with a Model 785 (1Mc) and a Model 705A (100Kc)



NOTE: Dimensions are based on the use of an Amphenol "MIP" socket mounted above the chassis.

The drawing shows the chassis dimensions for mounting Models 795, 785, and 705 DCU's side by side. Spacing between all units (or additional units) is identical.

FIGURE 1.

MOUNTING DIMENSIONS FOR MODEL 785 OR 795 DECIMAL COUNTING UNIT

INPUT REQUIREMENTS

A negative pulse of 6 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.025 microseconds, and the duration not more than 0.05 μseconds.

OUTPUT CHARACTERISTICS

The output is a negative pulse as shown in figure 7 (waveform taken at pin 4 of P101). The pulse is 7v in amplitude and 0.25 microseconds wide. This pulse is of proper amplitude to drive a Model 785 DCU.

METHOD OF RESETTING TO ZERO

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 8 of the 11-pin socket.

BINARY-CODED READOUT

The output at pins 2, 6, 9 and 10 of the DCU plug may be used to operate another binary-coded readout or printing device. Refer to the Binary Readout Code on page 5 to learn the relationship between binary digits and the plug terminal pins.

CIRCUIT DESCRIPTION

THE BINARIES

The Model 795 DCU contains four "flip-flop" circuits referred to here as binaries. These circuits are modifications of the Eccles-Jordan trigger circuit.

Figure 2 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R3 and R7, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

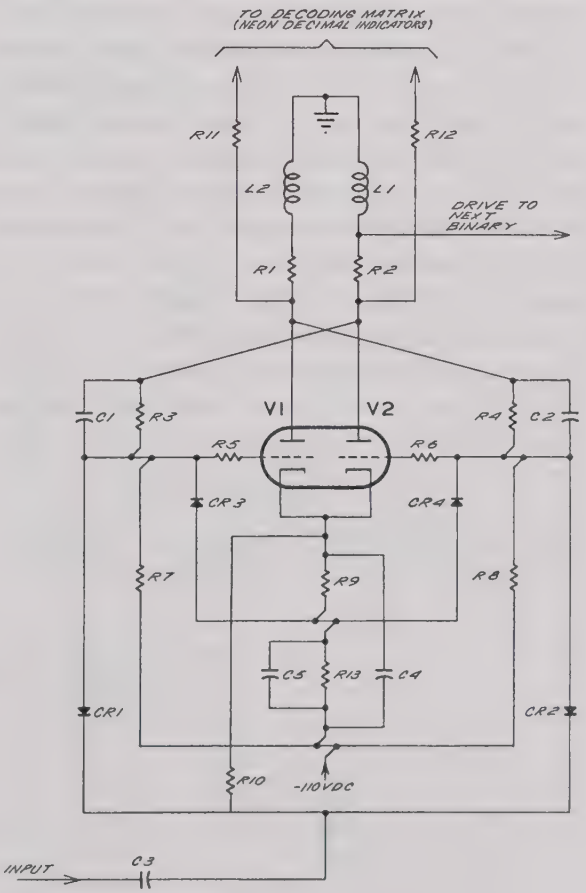


FIGURE 2.

A TYPICAL BINARY STAGE

The circuit is triggered from one state to another by negative pulses applied at the input. The input diodes CR1 and CR2 form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 30 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 22 volts. CR1 will not conduct since its plate is negative of 22 volts.

However, CR2 will conduct and the negative pulse at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cut-off. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, re-enforces the negative pulse there. This regenerative action proceeds rapidly until V2 is cut-off and V1 is conducting at a steady rate. The next adequate input pulse causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input pulses applied, making it a scale of two. The output is a negative pulse produced by peaking coil L1 when the right triode conducts and its plate voltage drops. This output, consisting of one negative pulse for every two input pulses, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built. A chain of three cascaded binaries would be a scale-of-eight (2^3). If we call the input pulses driving such a chain "counts", the operation may be described as follows. The first binary will produce a negative pulse upon counts 2, 4, 6 and 8. The second binary will generate output pulses at counts 4 and 8, and the third binary will produce a pulse only at count 8. Count 8 completes a full cycle; the binaries will then be in the same state they were in before the first count.

THE SCALE OF TEN

In the Model 795 three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 3 is a block diagram of the circuit.

At the beginning of a cycle the gate control binary is in the state which holds the gate open. For the first three counts (that is, counts 1 thru 3) the unit operates like a simple binary counter. At count 4 the third binary is triggered for the first time and, in turn triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse which triggers the gate control binary back to the "open" state. During counts 7, 8, 9 and 10 the unit again operates like a simple binary chain. At count 10 the third binary produces a negative output pulse which will drive another decimal counting unit.

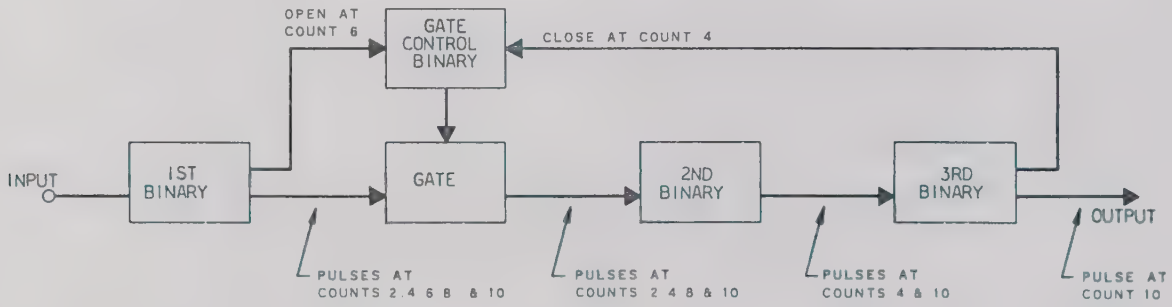


FIGURE 3.

BLOCK DIAGRAM OF MODEL 795 DCU

The operating sequence of the DCU is summarized in Table 1 below which shows the state of each binary for each registered count score. The state of a binary is defined by whether or not triode B is conducting. "0" means triode B is conducting; "1" means triode B is cut off. The "4th" binary is the gate control binary.

TABLE 1

Count Display	State of Each Binary Stage 4th	3rd	2nd	1st
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	1	1	0	0
5	1	1	0	1
6	0	1	0	0
7	0	1	0	1
8	0	1	1	0
9	0	1	1	1
0	0	0	0	0

Figure 4 shows how plate voltages throughout the unit change as successive counts are received. Voltage waveforms are identified by circled numbers corresponding to reference points located on the schematic diagram. The output voltage used to drive succeeding binaries is taken from the junction of a plate load resistor and an RF peaking coil rather than from the plate itself. The waveforms at this junction are negative pulses which occur when plate current increases and plate voltage drops.

The negative pulses, coinciding with negative transients in figure 4, drive succeeding binaries. The gate tube (V105) is driven by negative pulses from the first binary. The gate tube passes the pulse occurring on counts 2, 4, 8 and 10. A negative pulse from the gate at count 6, which would normally reach the second binary, is blocked by the action described in the following paragraph.

At count 4, the third binary switches states. The resulting positive transient at plate B is accompanied by a simultaneous negative transient at plate A. The negative transient, coupled to grid B of the gate control binary, causes this binary to switch to a state in which triode A is conducting. The resulting negative potential at plate A is applied to the grid of triode B in the gate tube. This closes the gate by cutting off triode B, so that the negative pulse generated by the first binary at count 6 cannot reach the second binary. However, this pulse is coupled from the cathode of the gate tube to grid A of the control binary. There, it cuts off triode A, thus returning the control binary to its original stable state and reopening the gate to pass a pulse to the second binary at count 8.

BINARY CODED ELECTRICAL READOUT

The output voltages of each binary are also brought out to pins 2, 6, 9 and 10 of the DCU plug to operate auxiliary binary-coded readout devices. Observe that voltage at pin 6 combines the output of the second binary and the output of triode B of the control binary while the voltage at pin 10 combines the output of the third binary with that of triode A of the control binary. The resultant modified binary code given in Table 2 agrees with that generated by other Beckman instrument. In the table "0" represents a voltage of -12v or more negative with respect to ground; "1" represents a voltage at ground level or positive of ground.

TABLE 2

BINARY READOUT CODE

Count Display	Pin on DCU Plug 10th	9th	6th	2nd
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1
0	0	0	0	0

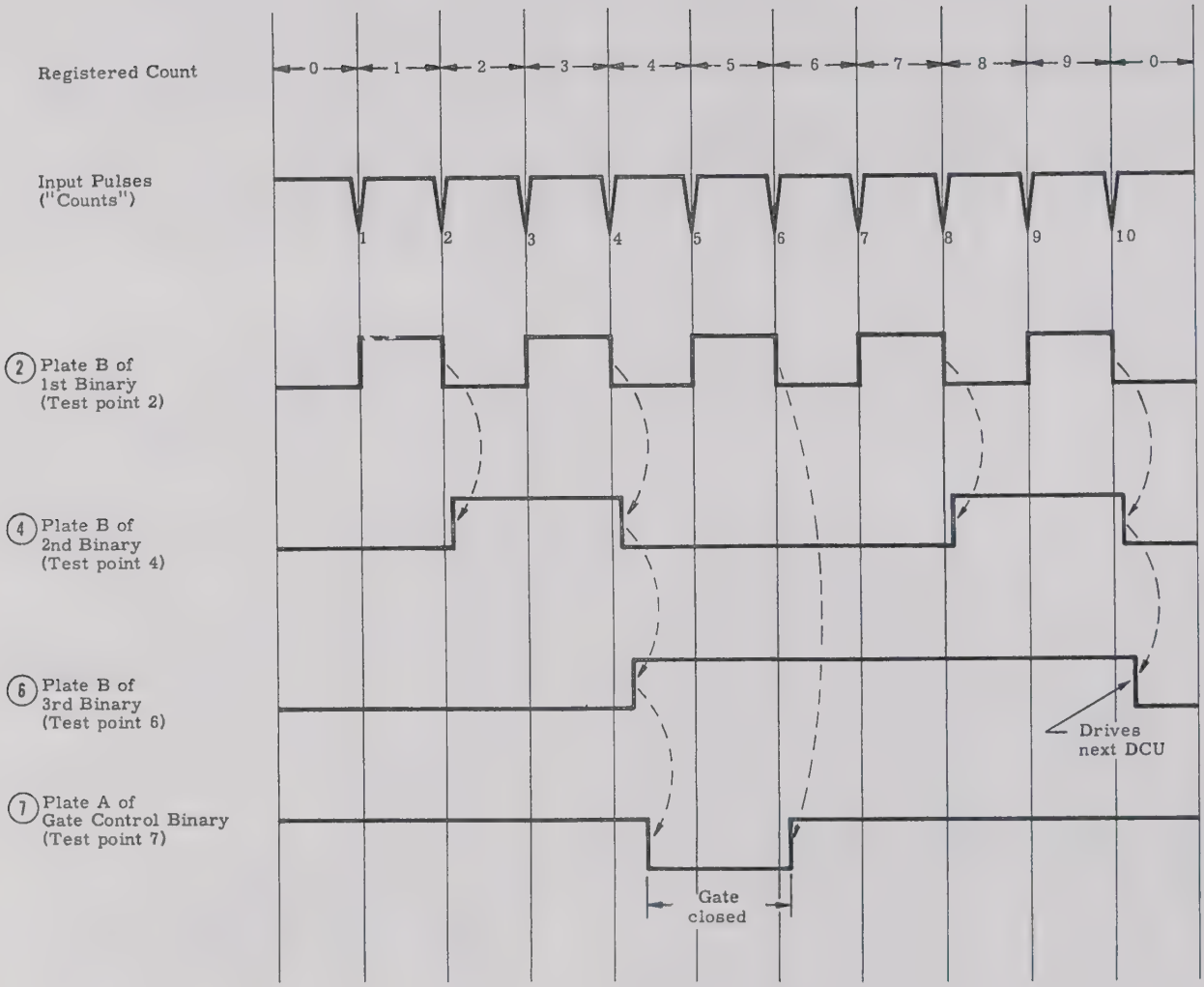


FIGURE 4. IDEALIZED WAVEFORMS.

The negative switching transients trigger succeeding binary stages as indicated by dashed lines. The positive transient at plate B of the 3rd binary is accompanied by a negative transient at plate A which actually triggers the gate control binary. Notice that the gate, although opened by a pulse from the 1st binary at count 6, does not open soon enough to pass this pulse to the 2nd binary. See figure 7 for actual waveforms.

THE DECODING MATRIX

As the DCU cycles from a registered count of 0 through a registered count of 9, ten discreet combinations of binary states are produced. Any particular combination is represented by eight dc voltage levels, one from each plate of each of the four binaries. These voltages are applied to a decoding matrix consisting of a network of resistors, diodes and neon bulbs. The voltages at the plates of the first binary, V101A and V101B, are amplified by V106A and V106B before application to the matrix. The matrix contains a set of "and" gates, constructed in such a way as to apply breakdown potential across a neon bulb only when the combination of dc voltages representing that bulb number occurs.

Table 3 shows the plate voltages applied to the decoding matrix during each of the ten discreet states of the unit. "H" denotes a "high" voltage; that is, the voltage produced at the plate when the triode is cut off. "L" denotes a "low" voltage; that is, the voltage created when the triode is conducting. The "H" voltage is always positive with respect to the "L" voltage, but whether it is actually a higher voltage with respect to ground depends upon at what point the triode plate circuit is grounded. In some triode circuits the B+ point is grounded, so that all plate voltages are negative with respect to ground, the "H" voltage being less negative than the "L" voltage.

Registered Count		0	1	2	3	4	5	6	7	8	9
Binary Code	1st binary (V101)	0	1	0	1	0	1	0	1	0	1
	2nd binary (V102)	0	0	1	1	0	0	0	0	1	1
	3rd binary (V103)	0	0	0	0	1	1	1	1	1	1
	4th binary (V104)	0	0	0	0	1	1	0	0	0	0
To Plate of	Neon Lamp	To Plate of									
V106B	0	V102B	L*	L*	H	H	L	L	L	L	H	H
V106A	1	V103B	L*	L*	L	L	H	H	H	H	H	H
V106B	2	V102A	H	H	L*	L*	H	H	H	H	L	L
V106A	3	V103B	L	L	L*	L*	H	H	H	H	H	H
V106B	4	V104A	H	H	H	H	L*	L*	H	H	H	H
V106A	5											
V106B	6	V102B	L	L	H	H	L	L	L*	L*	H	H
		V103A	H	H	H	H	L	L	L*	L*	L	L
V106A	7	V104B	L	L	L	L	H	H	L*	L*	L	L
V106B	8	V102A	H	H	L	L	H	H	H	H	L*	L*
V106A	9	V103A	H	H	H	H	L	L	L	L	L*	L*

TABLE 3

DECODING SCHEME: BINARY STATES TO DECIMAL DIGITS
See "The Decoding Matrix" for explanation.

For a lamp to light, the plate connected to the left-hand terminal (as shown in the table) must be "high" and all plates connected to the right-hand terminal must be "low". The voltages at the left-hand terminals determine whether an even-numbered or an odd-numbered lamp will light. When the registered count is an even number, the plate of V106B is high and the plate of V106A is low; when the registered count is odd these voltages are reversed. The voltage at the right-hand terminals determine which of the five odd-even pairs (0 & 1, 2 & 3, 4 & 5, 6 & 7 or 8 & 9) will have an opportunity to light. Notice that for any given registered count, only one pair will be connected to plates, all of which are low. These points are marked by an asterisk in the table.

To take an example, suppose the registered count is 3. Searching the column under "3" we find that two low plates (V102A & V103B) are connected to neon pair 2 & 3. This provides the necessary "low" voltage at the right-hand terminals of the bulbs. Since 3 is an odd number, the plate of V106A is high and that of V106B, low. Therefore, neon 3, connected between high and low voltages, lights, whereas neon 2 remains extinguished.

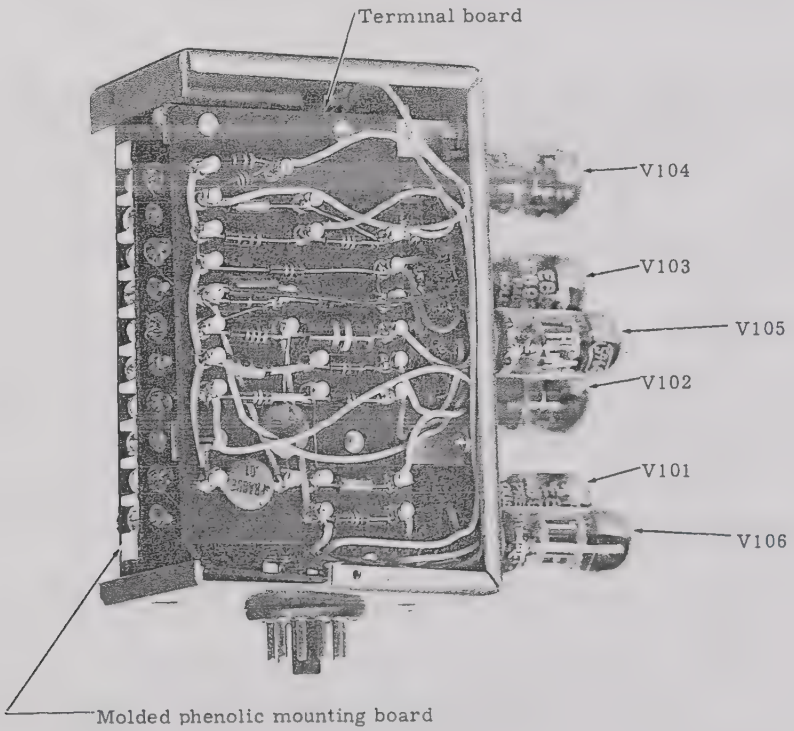


FIGURE 5.

Interior view of counting unit.

SERVICING

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

The Troubleshooting Chart lists some common troubles which may be readily localized by observing the lighting patterns. Figure 8 shows actual oscilloscope waveforms to be used for comparison. These pictures were taken using an input frequency of 10 megacycles. The waveshapes differ slightly and peak-to-peak voltages are smaller than at lower frequencies. Voltage and resistance measurements at tube pins are given in table 4.

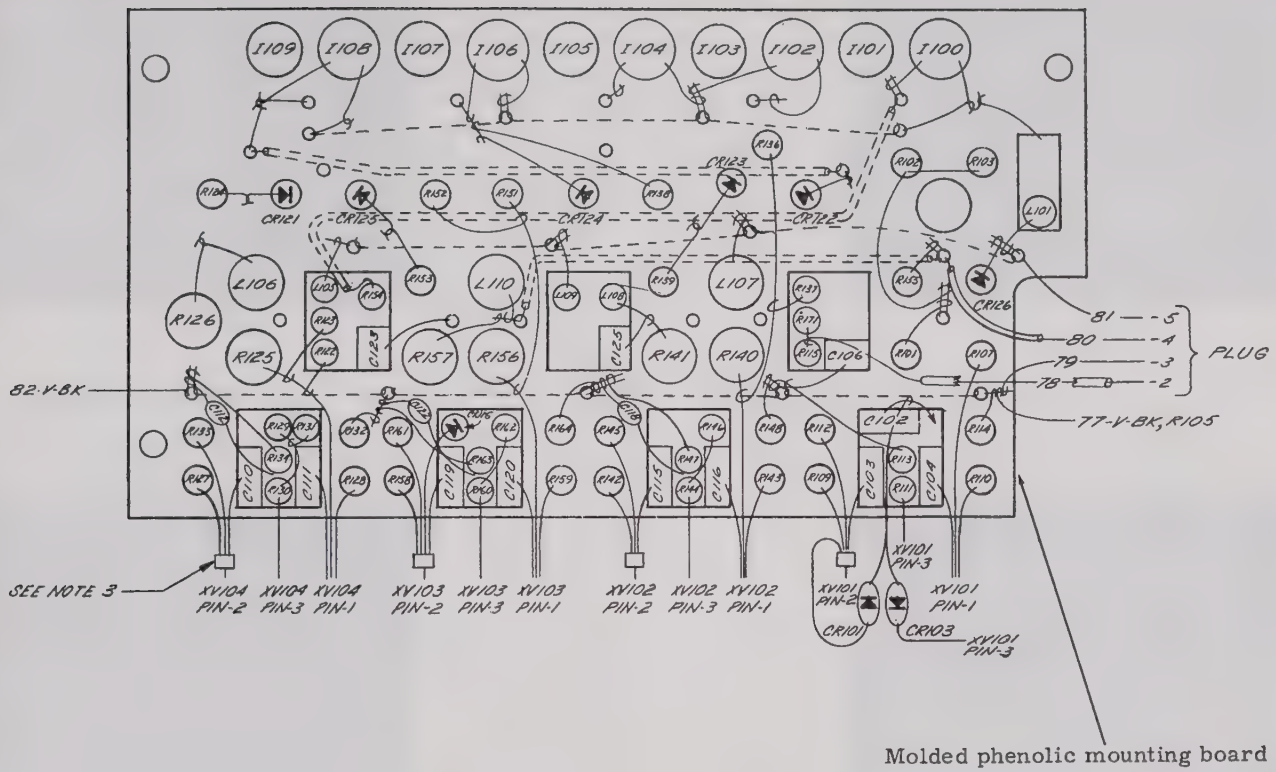
Locating the source of erratic operation is sometimes difficult because a feedback loop from the 3rd binary, through the 4th binary to the 2nd binary, makes all these stages interdependent. A failure in one stage will cause all to misfunction. To facilitate troubleshooting, the feedback loop can be broken by removing the 4th binary tube (V104). The DCU then becomes a simple chain of three binaries, V101, V102 and V103. These binaries form a scale-of-eight, so that if all three are operating correctly the unit will cycle through eight rather than ten discreet states. At slow speeds this produces the indicating sequence 0-1-2-3-6-7-8-9. At higher speeds output waveforms will appear as square waves, each binary producing waves at half the frequency and twice the pulse width of the preceding binary. Since there is no interaction between stages, trouble can be located by straightforward signal tracing.

Trouble in the binary stages (V101 thru V104) can be distinguished from troubles in the decoding circuitry by comparing binary output waveforms with the lighting sequence. If waveforms are correct but lighting sequence is erroneous, trouble lies in the decoding circuitry. It will be found that most failures are caused by faulty tubes or crystal diodes.

TROUBLESHOOTING CHART

NOTE: Reset unit before testing for symptoms.

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First binary stage inoperative
Unit counts spuriously without input signal	(a) Stray input signal (b) Pulses received through power supply
Unit counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component
Unit counts in wrong sequence	
1. Skips every other number	(a) First binary stage (V101) defective (b) Input circuit supplies double pulses
2. Skips 4 and 5	(a) 4th binary stage (V104) not being driven by the 3rd (V103)
3. Skips 6 and 7	(a) Gate tube (V105) not being driven by V104
Repeats a pattern of numbers	
1. Two stable states per cycle (0-1 or 2-3, etc.)	(a) 2nd binary stage (V102) not being driven (b) Defective gate tube (V105)
2. Four stable states per cycle (0-1-2-3 or 6-7-8-9)	(a) 3rd binary stage (V103) not being driven
3. Counts up to 5, then alternates between 4-5	(a) 4th binary stage (V104) not being driven by the 1st (V105)
Two or more lamps light simultaneously	Defective amplifier stage (V106)
Skips one number on indicator but binary-coded output count is correct	Defective neon lamp



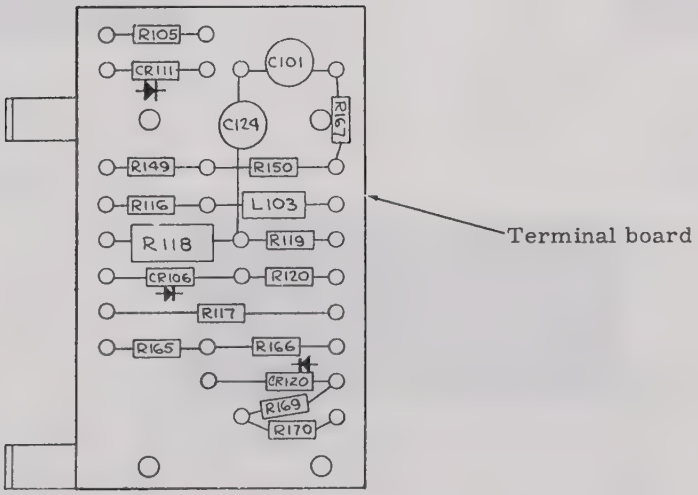
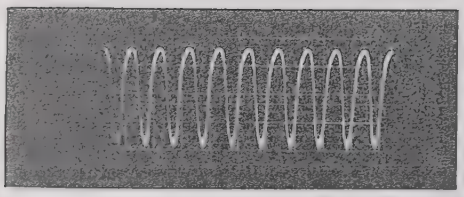
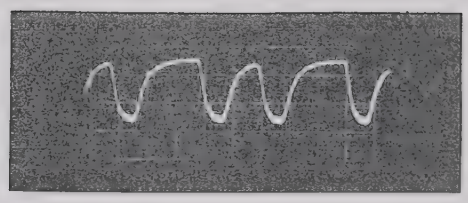


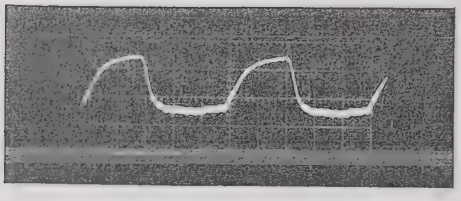
FIGURE 6.
PARTS LOCATION



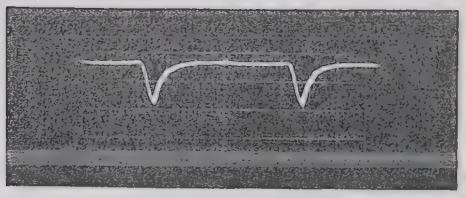
(1) 1st binary, plate A
V101, pin 1
10v/em, 0.2μsec/cm
Top grid line is ground level.



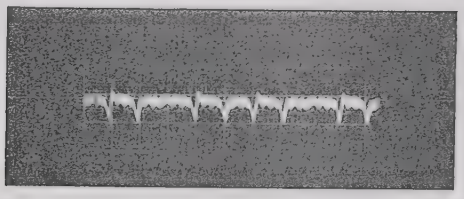
(3) 2nd binary, plate A
V102, pin 1
20v/cm, 0.2μsec/cm
Top grid line is ground level.



(5) 3rd binary, plate A
V103, pin 1
20v/cm, 0.2μsec/cm
Top grid line is ground level.



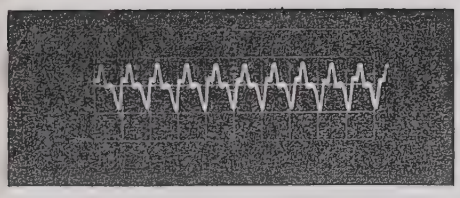
(7) Gate control binary, plate A
V104, pin 1
20v/cm, 0.2μsec/cm
Top grid line is ground level.
Gate is closed by negative pulse.



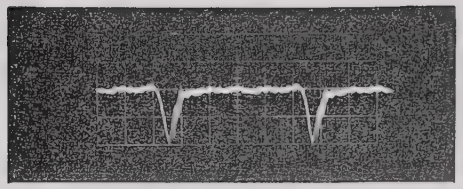
(9) Gated pulses to 2nd binary
V105, pin 1
5v/cm, 0.2μsec/cm, Scope ac-coupled.
Picture shows two complete DCU cycles starting with a registered count of zero. Negative pulses occur at counts 2, 4, 8 & 10. No pulse occurs at count 6.

FIGURE 7a

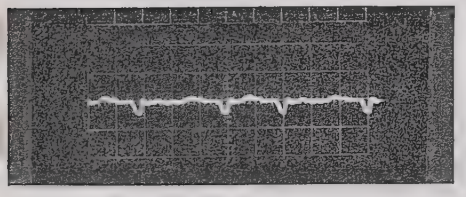
Typical waveforms with input frequency of 10Mcs.
Each picture shows two complete DCU cycles
starting from a registered count of zero.



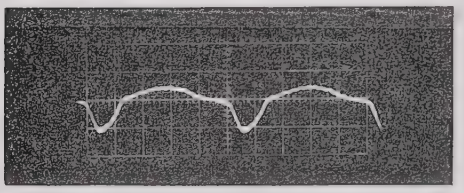
ate signal to gate control binary
105, pin 7
v/cm, 0.2μsec/cm, Scope ac-coupled.
legative pulses occur every even-numbered count.
ulse at count 6 triggers control binary.



Gating signal at gate
V105, pin 6
5v/cm, 0.2μsec/cm
Grid line second from top is ground level.
Gate is closed when voltage at this point is -10v or more negative with respect to ground.



Drive pulses to 3rd binary.
Junction of L108 & R141.
5v/cm, 0.2μsec/cm
Center horizontal grid line is ground level.
Pulses occur at counts 4 and 10.



Output of DCU
P101, pin 4
5v/cm, 0.2μsec/cm
Negative transients drive next DCU.

FIGURE 7b

Typical waveforms with input frequency of 10Mcs.
Each picture shows two complete DCU cycles
starting from a registered count of zero.

VOLTAGES

Table 4a

Note: Voltages measured to ground at registered count "0" with a vacuum tube voltmeter such as an RCA Volt-ohmyst Senior. B+ voltage is 120 volts. B- voltage is -110 volts. Voltages may vary ±10% due to component tolerances and tube variations.

Tube	Voltages at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	-3.5	-90	-85	Fil	Fil	-35	-85	-85	-85
V102	-6.5	-90	-85	Fil	Fil	-50	-85	-85	-85
V103	-9	-90	-85	Fil	Fil	-54	-85	-85	-85
V104	-6.5	-90	-85	Fil	Fil	-50	-85	-85	-85
V105	+96	+96	Fil	Fil	0	-5	0		
V106	+20	-7.5	Fil	Fil	-2.5	-35	-25		

RESISTANCES

Table 4b

Note: Resistances are measured to chassis ground with the DCU removed from its socket. Where path to ground goes through a diode, resistance reading depends upon polarity and magnitube of voltage applied by ohmmeter. These readings taken with RCA Volt-ohmyst Senior with negative terminal to chassis ground. Applied voltage was approximately 1.5v.

Tube	Resistances at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	2.1K	9.6K	7.5K	∞	∞	2.1K	9.6K	7.5K	7.5K
V102	3.9K	10.5K	7.8K	∞	∞	3.9K	10.5K	7.8K	7.8K
V103	3.9K	10.5K	7.8K	∞	∞	3.9K	10.5K	7.8K	7.8K
V104	3.2K	10.5K	8K	∞	∞	3.9K	10.5K	8K	8K
V105	100K	100K		∞	0	3.1K	20K		
V106	300K	300K		∞	110K	110K	135K		

PARTS LIST

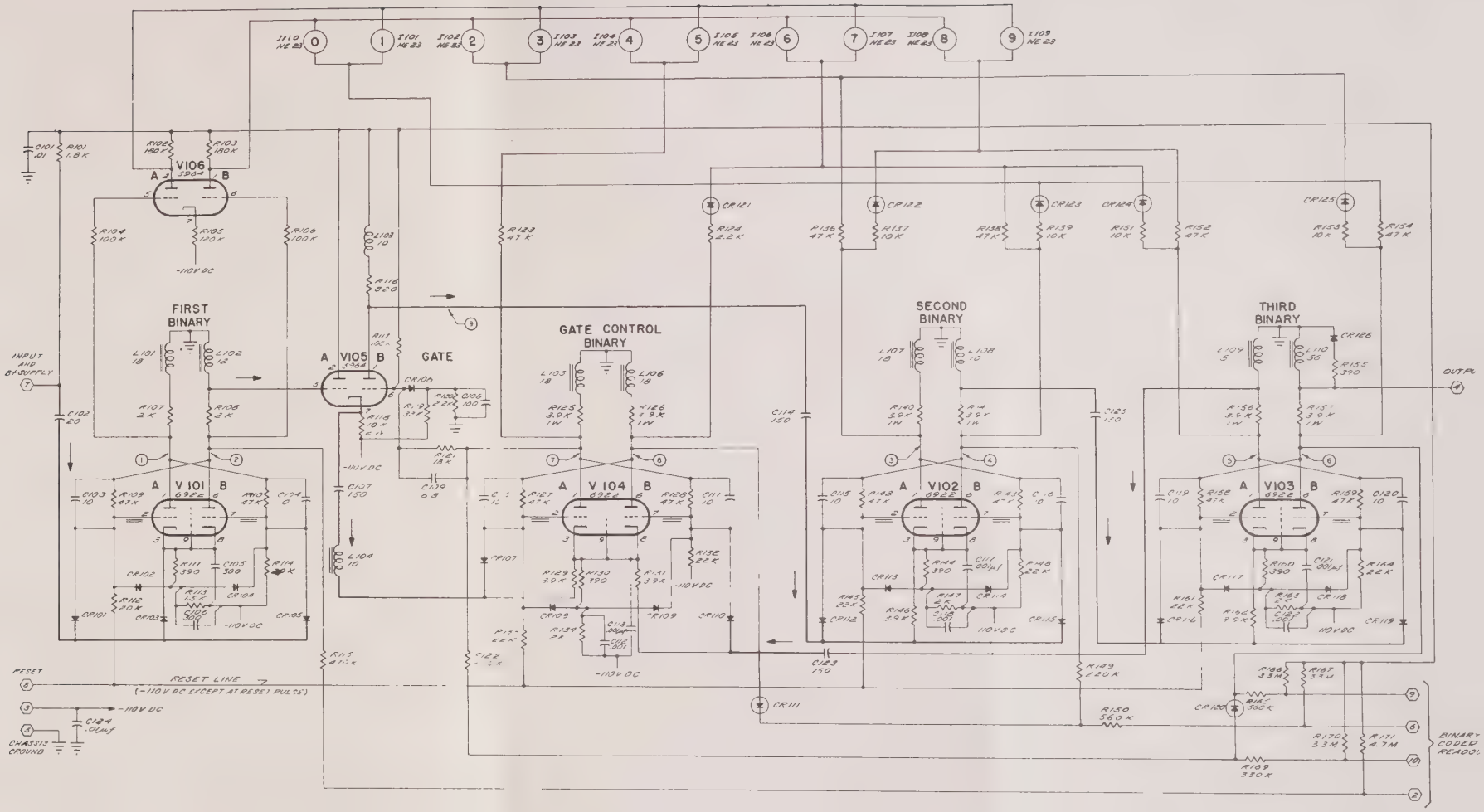
Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty.
C101	633-804717	Capacitor, 0.01μf, Disc, Axial Leads	Sprague 29C9	2
C102	637-804739	Capacitor, 20pf, 500V dc, S. Mica	Sangamo RR 1420	1
C103	637-807482	Capacitor, 10pf, 500V dc, S. Mica	Sangamo RR 1410	8
C104		Same as C103		
C105	637-804768	Capacitor, 300pf, 300V dc, S. Mica	Sangamo	2
C106		Same as C105		
C107	637-804761	Capacitor, 150pf, 500V dc, S. Mica	Sangamo RR 1315	4
C108	637-819113	Capacitor, 100pf, 500V dc, S. Mica	Sangamo CM 15	1
C109	633-804658	Capacitor, 6.8pf, 600Vdc, Cerm, Tubular	Erie GP1K	1
C110 & C111		Same as C103		
C112	633-804706	Capacitor, 0.001μf, Disc	Centralab DD 102	6
C113		Same as C112		
C114		Same as C107		
C115 & C116		Same as C103		
C117 & C118		Same as C112		
C119 & C120		Same as C103		
C121 & C122		Same as C112		
C123		Same as C107		
C124		Same as C101		
C125		Same as C107		
CR101	755-409096	Diode	Sylvania 1N198	19
CR102 thru CR110		Same as CR101		
CR111	755-404593	Diode, Special	B/B	7
CR112 thru CR119		Same as CR101		
CR120 thru CR125		Same as CR111		
CR126		Same as CR101		
I101	825-815972	Lamp, NE 23	GE	10
I102 thru I110		Same as I101		
L101	795-807887	Choke, 18μH, Molded	Nat. Coil QA-18-I	5
L102	795-807880	Choke, 12μH, Molded	Nat. Coil NA-12-I	1
L103	795-807878	Choke, 10μH, Molded	Nat. Coil NA-10-I	3
L104		Same as L103		
L105 thru L107		Same as L101		
L108		Same as L103		
L109		Same as L101		
L110	795-807896	Choke, 56μH, Molded	Nat Coil RA-56-I	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty.
	783-807862	Choke, Shielding Bead	Ferroxcube Corp. 255T118A205	8
P101	678-806896	Connector, 11 Pin Octal Plug	Amphenol 86-CP11	1
R101	601-015449	Resistor, F.Comp., 1.8k, 1/2W, 5%	Allen Bradley EB1825	1
R102	601-015081	Resistor, F.Comp., 180k, 1/2W, 5%	Allen Bradley EB1845	2
R103		Same as R102		
R104	601-015074	Resistor, F.Comp., 100k, 1/2W, 5%	Allen Bradley EB1045	3
R105	601-015077	Resistor, F.Comp., 120k, 1/2W, 5%	Allen Bradley EB1245	1
R106		Same as R104		
R107	601-015042	Resistor, F.Comp., 2k, 1/2W, 5%	Allen Bradley EB2025	5
R108		Same as R107		
R109	601-015064	Resistor, F.Comp., 47k, 1/2W, 5%	Allen Bradley EB4735	13
R110		Same as R109		
R111	601-015444	Resistor, F.Comp., 390Ω, 1/2W, 5%	Allen Bradley EB3915	5
R112	601-015057	Resistor, F.Comp., 20k, 1/2W, 5%	Allen Bradley EB2035	2
R113	601-008129	Resistor, F.Comp., 1.5k, 1/2W, 5%	Allen Bradley EB1525	1
R114		Same as R112		
R115	601-015086	Resistor, F.Comp., 470k, 1/2W, 5%	Allen Bradley EB4745	1
R116	601-079172	Resistor, F.Comp., 820Ω, 1/2W, 5%	Allen Bradley EB8215	1
R117		Same as R104		
R118	601-015053	Resistor, F.Comp., 10k, 2W, 5%	Allen Bradley HB1035	1
R119	601-015060	Resistor, F.Comp., 33k, 1/2W, 5%	Allen Bradley EB3335	1
R120	601-000897	Resistor, F.Comp., 2.2k, 1/2W, 5%	Allen Bradley EB2225	2
R121	601-015056	Resistor, F.Comp., 18k, 1/2W, 5%	Allen Bradley EB1835	1
R122	601-015083	Resistor, F.Comp., 220k, 1/2W, 5%	Allen Bradley EB2245	2
R123		Same as R109		
R124		Same as R120		
R125	601-023764	Resistor, F.Comp., 3.9k, 1W, 5%	Allen Bradley GB3925	6
R126		Same as R125		
R127 & R128		Same as R109		
R129	601-015047	Resistor, F.Comp., 3.9k, 1/2W, 5%	Allen Bradley EB3925	4
R130		Same as R111		
R131		Same as R129		
R132	601-000565	Resistor, F.Comp., 22k, 1/2W, 5%	Allen Bradley EB2235	6
R133		Same as R132		
R134		Same as R107		
R136		Same as R109		
R137	601-015052	Resistor, F.Comp., 10k, 1/2W, 5%	Allen Bradley EB1035	4
R138		Same as R109		
R139		Same as R137		
R140 & R141		Same as R125		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty.
R142 & R143		Same as R109		
R144		Same as R111		
R145		Same as R132		
R146		Same as R129		
R147		Same as R107		
R148		Same as R132		
R149		Same as R122		
R150	601-001554	Resistor, F.Comp., 680k, 1/2W, 5%	Allen Bradley EB6845	1
R151		Same as R137		
R152		Same as R109		
R153		Same as R137		
R154		Same as R109		
R155		Same as R111		
R156 & R157		Same as R125		
R158 & R159		Same as R109		
R160		Same as R111		
R161		Same as R132		
R162		Same as R129		
R163		Same as R107		
R164		Same as R132		
R165	601-015087	Resistor, F.Comp., 560k, 1/2W, 5%	Allen Bradley EB5645	1
R166	601-800013	Resistor, F.Comp., 3.3m, 1/2W, 5%	Allen Bradley EB3355	3
R167		Same as R166		
R169	601-017528	Resistor, F.Comp., 330k, 1/2W, 5%	Allen Bradley EB3345	1
R170		Same as R166		
R171	601-012458	Resistor, F.Comp., 4.7m, 1/2W, 5%	Allen Bradley EB4755	1
V101	751-800265	Tube	Amperex E88CC/6922	4
V102 thru V104		Same as V101		
V105	751-800257	Tube	RCA 5964	2
V106		Same as V105		
XV101	860-802350	Socket, 9Pin, w/o tube Shield, w/center Shield	Elco 274	4
XV102 thru XV104		Same as XV101		
XV105	860-818332	Socket, 7Pin, w/o tube Shield, w/center Shield	Elco STCP 108 PHSPTD	2
XV106		Same as XV105		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty.
	693-402920	Terminal Board	B/B	1
	327-402921	Terminal Board Bracket	B/B	2
	430-402917	Frame	B/B	1
	348-402816	Number Panel	B/B	1
	663-400448	Plug Retaining Wire	B/B	1
	349-402692	DCU Cover	B/B	2

SCHEMATIC DIAGRAM
MODEL 795
DECIMAL COUNTING UNIT



Model 795
D402915-Rev. K
February 1966

Beckman®

BECKMAN INSTRUMENTS, INC.

Electronic Instruments Division

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1422 Westmoor
Austin, Texas 78723
512-454-4465

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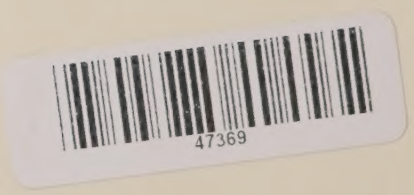
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